Science 4

Wheels, Gears, and Levers

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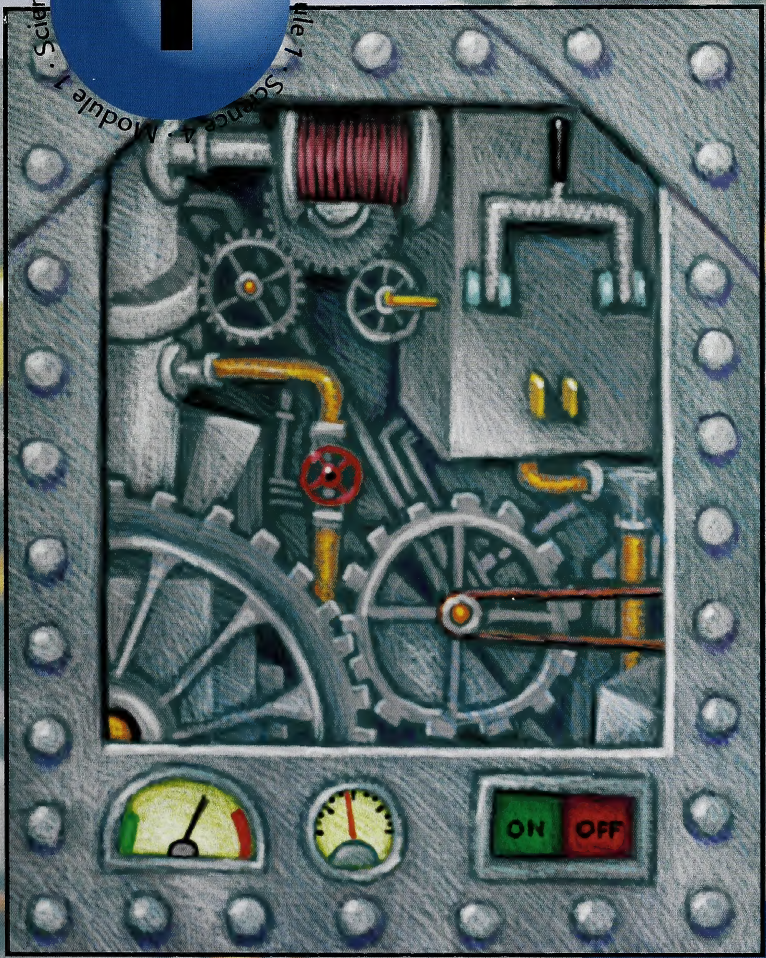

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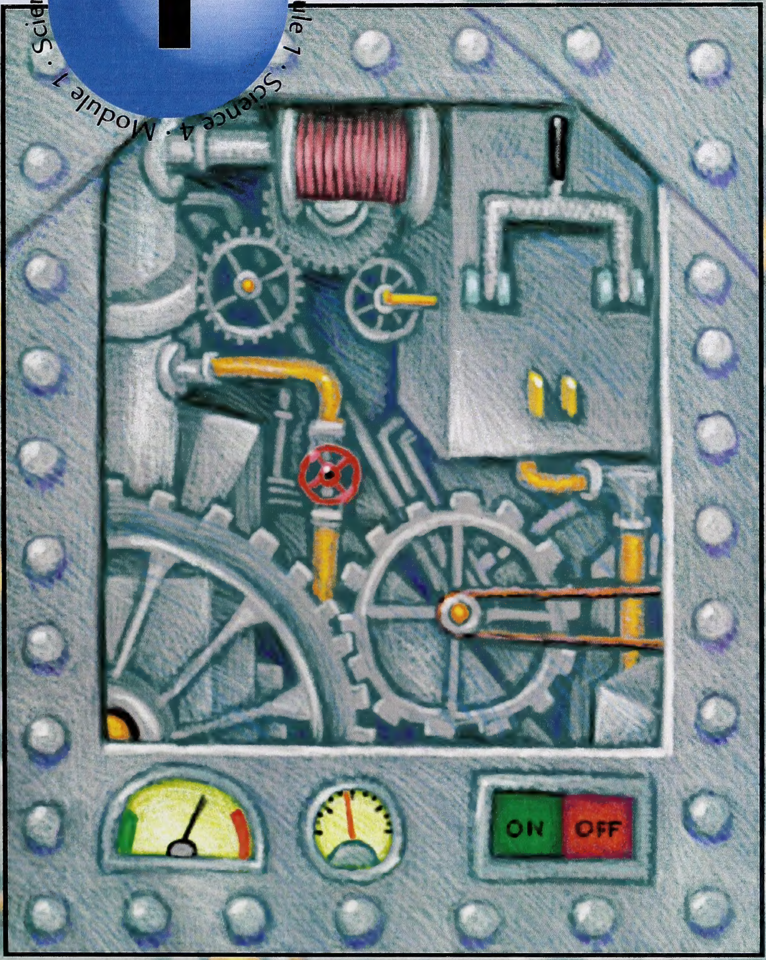

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Science 4
Module 1: Wheels, Gears, and Levers
Student Module Booklet
Learning Technologies Branch
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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	✓
General Public	
Other	

Internet Link

You may find the following Internet sites useful:

- Alberta Education, **http://www.education.gov.ab.ca**
- Learning Technologies Branch, **http://www.education.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.education.gov.ab.ca**

Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

Welcome

to Science 4

There are six modules in this course. It is recommended that you work through the modules in order because the concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

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Module 1
Wheels, Gears, and Levers

2

Module 2
Building Devices and Vehicles That Move

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Module 3
Light and Shadows

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Module 4
Plant Growth and Changes

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Module 5
Waste and Our World

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Module 6
Relationships

Contents

General Course Information

Course Features

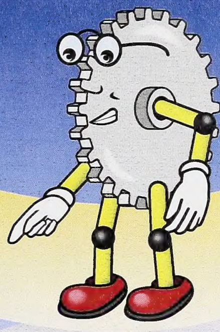
You will see many important features as you look through Science 4.

- Every module has a Module Overview, a Module Summary, and a Glossary.
- Every module has several sections. Each section groups lessons with a common theme.
- Every section has several lessons. Each lesson helps you work with an idea from science.
- Every lesson has an activity for you to work on and questions to answer.
- Every lesson ends with a list of new terms and the Suggested Answers. These answers give you a chance to find out quickly how you did. You may learn a lot from comparing your answers to the ones given there.
- Every module has a Glossary. It includes the new science terms introduced in the module.

Resources

In Science 4 you will complete activities that use things found around your home. Your home instructor will help you get these things together. Here is an example of a materials list.

- string
- a ruler
- a deck of cards



Other Resources

The Internet

You can use the Internet for research and learning. You will find Internet sites listed in your Student Module Booklets. You should also use other tools when you are doing research. For example, use your local library.

If you do use the Internet, you should keep these things in mind.

- Do not believe everything you read. There are lots of different sites on the Internet. Anyone can create one. You will have to decide if the information you find is correct. You have to think about the source of the information. Is it a museum or a science centre? If it is, you can probably accept the information as true.

- Use online research tools. You can use a number of different search engines to help you. They let you search for information by giving a few key words. Some search engines you can use are found at
  - **http://www.altavista.com**
  - **http://www.google.ca**
  - **http://www.yahoo.ca**

- Websites can change or disappear. If you come across a site like this, there are things you can do. You can go to a search engine and search for a key word or phrase. You can also use the WayBackMachine. They keep copies of many websites. Go to **www.archive.org** and enter the "missing address" in the WayBackMachine. Click the "Take Me Back" button. If you are lucky, you'll get the site you were looking for.

LearnAlberta

LearnAlberta.ca is a protected digital learning environment for Albertans. This Alberta Education portal, found at **http://www.learnalberta.ca**, is a place where you can support your learning by accessing resources for projects, homework, help, review, or study.

For example, LearnAlberta.ca contains a large Online Reference Centre that includes multimedia encyclopedias, journals, newspapers, transcripts, images, maps, and more. The National Geographic site contains many current video clips that have been indexed for Alberta Programs of Study. The content is organized by grade level, subject, and curriculum objective. Use the search engine to quickly find key concepts. Check this site often as new interactive multimedia segments are being added all the time.

If you find a password is required, contact your teacher or school to get one. No fee is required.

Special Features

The Student Module Booklets contain some special features.

- **A Great Scientist**
  These introduce great scientists. They are persons who have made, or are making, a big contribution to science. Their work is related to what you are studying. These women and men may be from the past or the present. They may be from Canada or anywhere in the world.

- **A Closer Look**
  These are items that extend what you are studying in the lesson. They give you a chance to learn slightly more complex or detailed information. They may also give you a different way to look at the topic. You should find them interesting and sometimes even funny.

- **Imagine**
  These are unusual or interesting science facts. They appear here and there in the Student Module Booklet.

Assessment and Feedback

Science 4 gives you many chances to see how well you are doing. One way is to use the Suggested Answers to check your responses. Comparing your answers to the given ones is one source of feedback. It can help you improve your understanding of science concepts and skills. It will also help you improve how you tell others about your ideas.

There are two Assignment Booklets for each module. You send them to your teacher for marking. When you get them back, your teacher will have made comments on your work. You should look over the comments carefully. You should also use the comments to improve your answers.

There is a Final Test to be taken at the end of the course. You can use the marked assignments to help you prepare for it. You should also ask your home instructor to help you review for the Final Test.

Visual Cues

New science terms are shown in bold and colour the first time they are used. You can read what they mean in the margin close to their first use. You can also look them up in the Glossary at the end of the module.

Throughout Science 4 you will see icons. They are visual clues to help you know what to do. Each icon reminds you to do something. The icons used in Grade 4 Science are shown here.

Check your answers with the Suggested Answers at the end of this lesson.

Use caution when doing this activity.

Ask your home instructor for help.

Collect some materials to do a science activity.

Use the Internet.

Turn to your Assignment Booklet.

Module Overview

All around you science is hard at work. Simple and complex machines are working to make our lives easier. Do you enjoy playing tennis, riding a bike, or playing hockey? Did you know that a tennis racket, a bicycle, and a hockey stick are all types of machines?

In this module, you will look at different types of simple machines and find out how they make work easier for us. Tightening a screw would be a very difficult task without a screwdriver. A screwdriver is a simple machine that helps us perform a task. You will also have a chance to make your own machines.

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Module 1
Wheels, Gears, and Levers

Section 1
Exploring Simple Machines

Section 2
Levers

Section 3
Drive Systems

How Will You Be Marked?

Your mark on this module will depend on how well you complete the two Assignment Booklets.

This is how the marks are distributed:

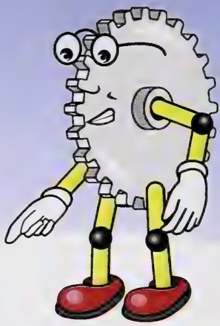
Assignment Booklet 1A	
Section 1 Assignment	36 marks
Total	36 marks
Assignment Booklet 1B	
Section 2 Assignment	36 marks
Section 3 Assignment	20 marks
Total	56 marks

Be sure to check with your teacher to see if this mark distribution is appropriate for you. Some teachers like to include other reviews and assignments. When you get the assignments back from your teacher, be sure to read the comments and talk about them with your home instructor.

When you do the assignments, work slowly and carefully under the instruction of your home instructor or teacher. You may use your course materials to help you, but you must do the assignments by yourself.

Section 1

Exploring Simple Machines



Introduction

When you open a door, use a shovel, or zip up your jacket, you are using simple machines. You use many different simple machines to perform everyday tasks. We take many of these machines for granted without thinking about what our lives would be like without them.

Could you imagine a world without zippers, for instance? It would take much longer to fasten clothing, gym bags, and tents!

In this section, you will explore how some types of simple machines work. You will try several experiments. You will see how these machines make work and movement easier.

Lesson 1: Inclined Planes

Suppose you had a choice of two paths to take up a steep hill. Would you take the shorter path that goes straight up the hill? Would the longer path that zigzags back and forth to the top be better?

If you took the zigzag trail you would walk farther. If you took the straight path, you would work harder. The zigzagging path is a type of **inclined plane**. Today you will see how inclined planes help us make hard tasks easier.

inclined plane: a simple machine with a slope, such as a ramp

What exactly is an inclined plane? An incline is a slope. A plane is a flat surface. An inclined plane is a sloped flat surface, such as a **ramp**. It is one type of **simple machine**. A **machine** is anything that helps us perform a task more easily. Machines don't have to be complex objects with lots of moving parts.

ramp: a sloped flat surface

simple machine: a basic machine like the inclined plane, lever, pulley, screw, wedge, and wheel and axle

machine: anything that helps us perform a task more easily

force: a push or a pull acting upon an object

Ramps, or inclined planes, help us move objects to a higher place. Inclined planes reduce the amount of **force** needed to lift an object. Have you seen ramps in front of buildings? People using walkers, wheelchairs, or electric scooters use ramps to enter buildings. So do people pushing baby strollers. Sidewalks (at corners) and driveways are built as inclined slopes. Can you guess why?

Activity 1: Easy Lifting

Find out for yourself
if an inclined plane
reduces the force you use.

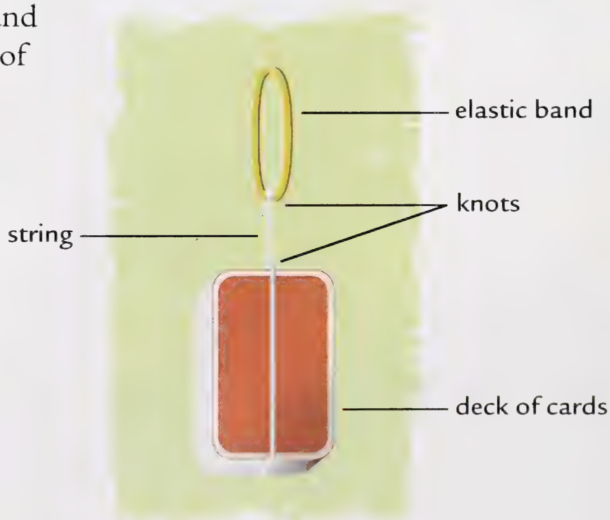
What you need

- string
- a deck of cards
- an elastic band
- a ruler
- a cookie sheet
- a stack of magazines or thin books

What to do

Look at the diagrams to help with this activity.

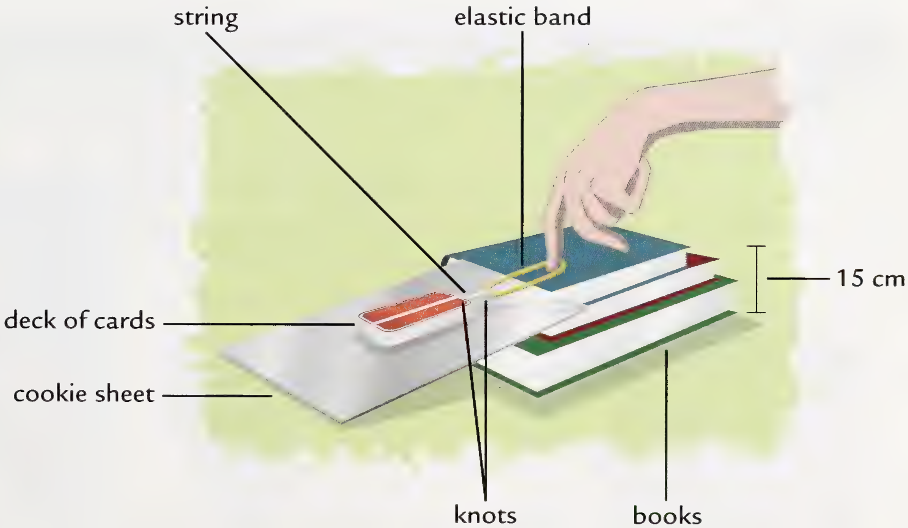
1. Loop one end of the string around the deck of cards and tie a knot. Leave a "tail" of string at the other end.
2. Tie the elastic band to the "tail" end of the string.



3. Hold on to the end of the elastic band and gently raise the deck of cards straight up 15 cm. Measure the length of the elastic band. Record this number in box **a.** of the following chart.

Action	Distance Moved to Reach a 15-cm Height	Length of Elastic Band (cm)
raising cards straight up 15 cm	15 cm	**a.**
raising cards 15 cm using ramp	**b.**	**c.**

4. Make a stack of magazines or books 15 cm high. Prop one end of the cookie sheet on the stack of books. This makes a ramp that raises a load 15 cm.



5. Measure the length of the cookie sheet (your ramp.) Record this length in box **b.** of the chart.

6. Place the deck of cards at the bottom of the cookie sheet. Use the elastic to gently pull the cards up your ramp. While the cards are moving, measure the length of the elastic band. Record this length in box **c.** of the chart.

7. Compare the lengths in boxes **b.** and **c**. This will show you which way of lifting took the most force. More stretching happens when you use more force.

Now answer the following questions.

8. Which method took more force? Circle your choice.

   a. lifting the cards straight up

   b. pulling the cards up the ramp

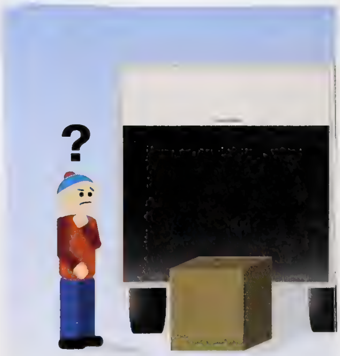
9. Which method used more distance? Circle your choice.

   a. lifting the cards straight up

   b. pulling the cards up the ramp

Check your answers for this activity in the Suggested Answers at the end of this lesson.

In Activity 1, you experimented with forces and inclined planes. An inclined plane reduces the force you use to move an object. You saw that there was a trade-off for this. If you use an inclined plane, you have to apply the force over a longer distance.



Suppose you had to put a heavy box onto the back of a truck. The truck box is 1 m above ground level.

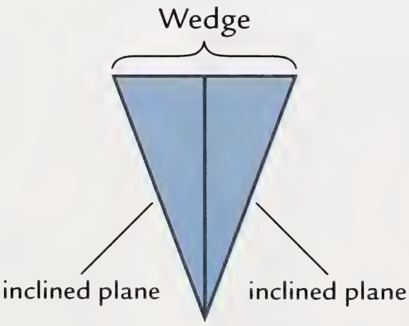
It would be hard to lift the box straight up onto the truck. However, you would have to move the box only 1 m. It would be easier if you used an inclined plane that was 4 m long. Sliding the box into the truck would use less **effort** but you would have to move the box 4 m instead of 1 m.

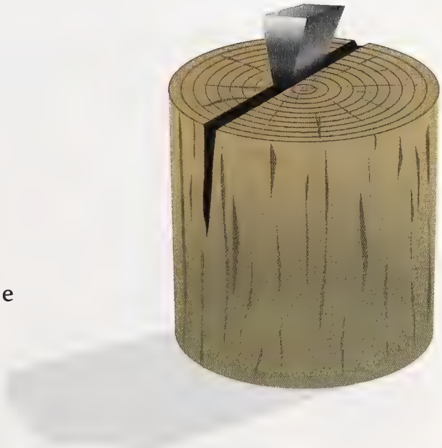
effort: force applied to a machine to move an object

Inclined Planes in Disguise

The **wedge** is another simple machine. It separates or splits materials. A wedge is two inclined planes together. Both sides of a wedge are the sloped sides of inclined planes. Instead of something moving up the inclined plane, the wedge itself moves.

wedge: a simple machine used to separate materials; two inclined planes together





An axe includes a wedge. The wedge part of the axe moves through wood to split it. Knives are also wedges.

Door locks and other types of locks use tiny wedges to work. Have you ever used a lock with a combination—perhaps on a locker at a swimming pool? The little clicks you may hear are moving wedges.

Zippers have been widely used only since World War I (the early 1900s). Inside the tab on a zipper are tiny wedges. One wedge opens the zipper. Two different wedges push the two sides of the zipper together.

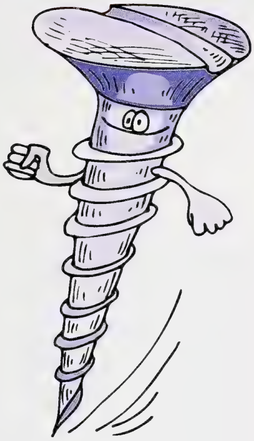
To see the inside of a combination lock, and how it works, and to see how a zipper works, go to the site How Stuff Works.

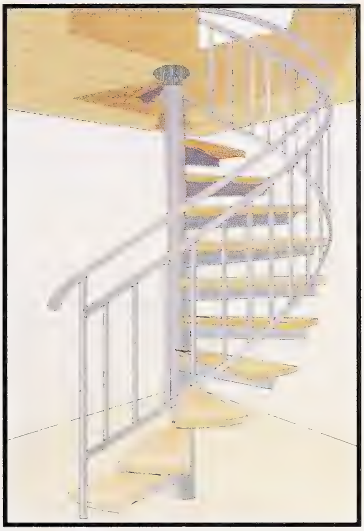
- http://www.howstuffworks.com/inside-lock.htm
- http://science.howstuffworks.com/zipper.htm

Ask your home instructor to visit this site with you. You may need some adult help at this site.

A screw is actually a small, coiled inclined plane. It is also a simple machine. Look closely at the screw in this picture. The **threads** wrap around it like a spiral staircase.

threads: sloping ridges that wind or coil around a screw, bolt, or jar lid





As you turn a screw, the threads coil into the piece of wood. You do not have to use much force to turn a screwdriver. You do have to make a lot of turns for the screw to get into the wood. (Remember, the threads of a screw are similar to a coiled ramp.) Compare this to the force you would need to push a nail the same distance. A nail travels straight into the wood. It travels a shorter distance, but it needs a lot of force to get there.

Have you ever noticed that screw heads and screwdriver tips have different shapes? Some are straight. Others are shaped like an X. There also are some with square shapes.

Imagine

A Canadian inventor, Peter Robertson, designed the Robertson screw and screwdriver in 1908. The screw has a square hole in the head. The tip of the screwdriver is also square and fits into the screw head.

The Robertson screw and screwdriver became popular because they had greater turning power than screws with a slot in them. If you want to know more, go to the Mysteries of Canada website.

Internet Link

http://www.mysteriesofcanada.com/Ontario/robertson_screws.htm

A screw may even help you turn the water on and off in your home. Take "A Closer Look" at a water faucet.

A CLOSER LOOK

Water Faucet

Even a water faucet is a machine. Did you know that when you turn a tap on or off, you have moved a screw inside the faucet?

When you turn off a tap, a screw with a washer (a rubber ring) at its lower end presses into a hole. This stops the flow of water. When you turn the tap on, the screw unwinds the other way—or is unscrewed—and the washer comes out of the hole. This allows the water to run out of the tap. When the rubber washer wears out, it does not fit in the hole properly. Some water leaks through and the tap drips.

To see how a faucet works, go to the following website.

Internet Link

http://www.digitalgizmo.com/projects/proj_faucetDemo.jsp

Turn to Assignment Booklet 1A and complete question 1 of Assignment 1.

Suggested Answers

Activity 1: Easy Lifting

3. Hold on to the end of the elastic band and gently raise the deck of cards straight up 15 cm. Measure the length of the elastic band. Record this number in box **a.** of the following chart.

5. Measure the length of the cookie sheet (your ramp.) Record this length in box **b.** of the chart.

6. Place the deck of cards at the bottom of the cookie sheet. Use the elastic to gently pull the cards up your ramp. While the cards are moving, measure the length of the elastic band. Record this length in box **c.** of the chart.

Action	Distance Moved to Reach a 15-cm Height	Length of Elastic Band (cm)
raising cards straight up 15 cm	15 cm	**a.** Answers will vary. The length will depend on the elastic and deck of cards used.
raising cards 15 cm using ramp	**b.** Answers will vary. The distance should be greater than 15 cm. (Many cookie sheets are 35 cm to 45 cm long.)	**c.** Answers will vary. The length of the elastic band raising the cards straight up should be longer than the length of the elastic band using the ramp.

8. Which took more force? Circle your choice.

   a. lifting the cards straight up

   b. pulling the cards up the ramp

You should have circled **a**. It takes more force to lift the cards straight up.

9. Which used more distance? Circle your choice.

   a. lifting the cards straight up

   b. pulling the cards up the ramp

   You should have circled **b**. More distance is used to pull the cards up the ramp.

Key Words

effort: force applied to a machine to move an object

force: a push or a pull acting upon an object

inclined plane: a simple machine with a slope, such as a ramp

machine: anything that helps us perform a task more easily

ramp: a sloped flat surface

simple machine: a basic machine like the inclined plane, lever, pulley, screw, wedge, and wheel and axle

threads: sloping ridges that wind or coil around a screw, bolt, or jar lid

wedge: a simple machine used to separate materials; two inclined planes together

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Lesson 2: Rollers and Wheels and Axles

It's a hot summer day. You have to get a big box of toys down the street to a friend's house. Do you think you would use a square-wheeled cart? How about a wooden sleigh? Perhaps, you'd just carry it. Or maybe, just maybe, you'd use a wagon. Why would the wagon be the best? It's because rolling is easier than carrying or sliding. This lesson helps you look at ways that rollers and wheels and axles make life easier.

friction: a force that opposes the motion between two objects in contact with each other

theory: a general rule that explains or predicts facts or events

Rollers, balls, and wheels are all different shapes, but they all roll. It's much easier to roll something across the floor than to slide it across the floor. There is less **friction**. Less friction means it's easier to move things.

Today, let's start with an activity using rollers. You get to test the **theory** that rolling things is less work than sliding them.

Activity 2: Easy Roller

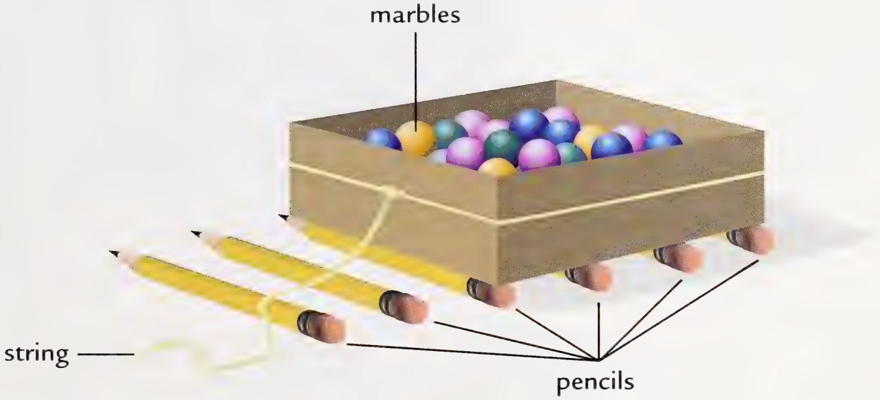
Is rolling a load
easier than sliding it?

What you need

- string
- several round pencils
- a small cardboard box, such as a shoe box
- rocks, marbles, or other objects to put in the box

What to do

Look at the diagram to help with this activity.



1. Fill the box with several marbles or rocks or similar objects.

2. Tie the string around the sides of the box and leave a long end to pull on.

3. Pull the box across the table. What do you notice?

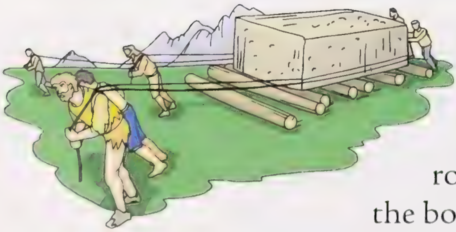
____

____

4. Place at least 4 pencils under the box. Put 2 or more pencils in front of the box. Line up all the pencils evenly. (See the diagram at the start of this activity.)

5. Pull the box across the table. Explain the difference between pulling the box with and without the pencils.

Check your answers for this activity in the Suggested Answers at the end of this lesson.



Huge 4000-kg blocks of stone make up the pyramids in Egypt. How were people able to move such huge rocks? There are many different ideas. One theory is that the workers rolled the stones on round logs. It was like rolling the box on pencils in Activity 2.

Rollers

Rollers are tube-like shapes (or cylinders). If you turn a tin can on its side, you have a roller. If you want to pull a small boat up a beach, you can first lay down some rollers, such as long, smooth poles. You would place them in the path of the boat and then pull the boat onto the rollers. Again, it's like your box-and-pencil activity.

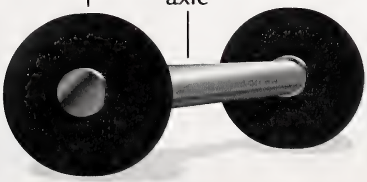
Roller conveyors also use rollers. A long line of rollers helps move heavy objects over a long distance.

Conveyor belts are quite similar. A belt covers the rollers and moves the object. For example, bags checked at an airport ride on a conveyor belt. Farmers may use conveyor belts when they store or stack bales of straw and hay up high.

Wheel and Axle

wheel and axle: a simple machine made up of an attached wheel and cylinder

A wheel is simply a new and improved version of a roller. A **wheel and axle** is a simple machine. The wheel is connected to a cylinder or rod (the axle). It acts like a roller.



Where have you seen a wheel and axle? You would probably guess correctly that they are found on vehicles. Did you know they are also found on the door to your room? When you turn a doorknob to open a door, you have used a wheel and axle.

In a wheel and axle, a wheel is attached to a cylinder or rod called the axle. If the wheel is turned, the axle also turns. If the axle is turned, the wheel also turns.

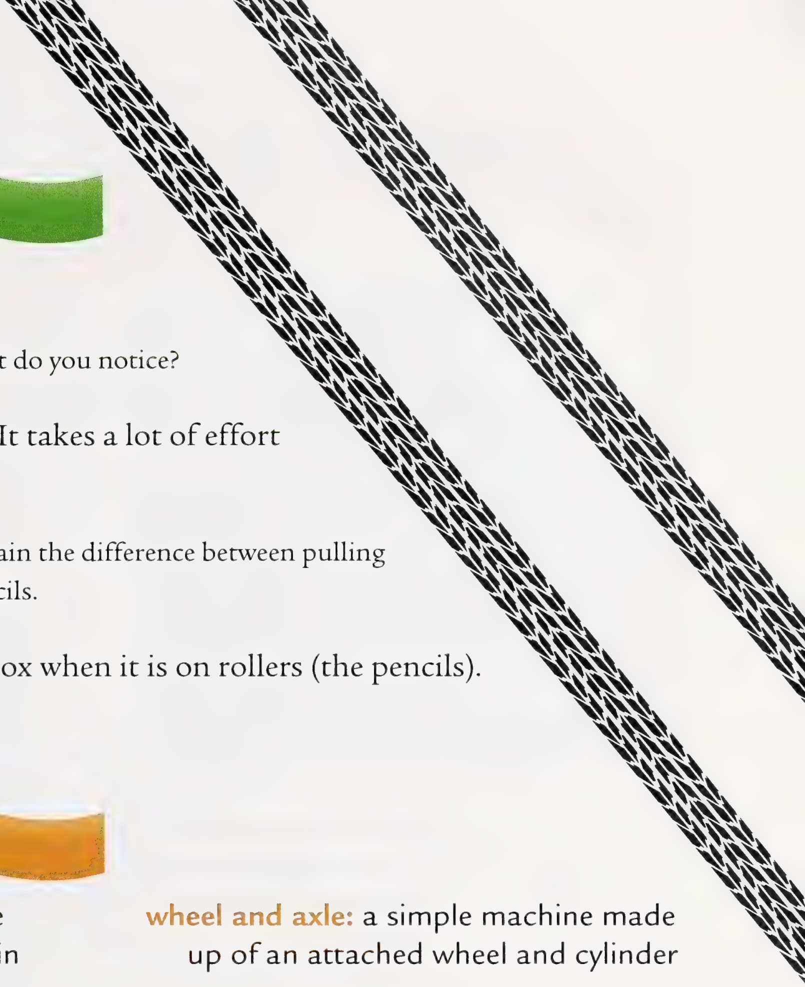
Think of a steering wheel in a car or even a go-cart. The part the driver holds is the wheel. The column that attaches to the wheel is the axle. The driver applies force to the wheel to steer the vehicle.

The most common use of the wheel and axle is to make vehicles move. When you pedal your bicycle, you apply force to the axle of the rear wheel. It turns, and the wheel turns with the axle. In cars and trucks, the engine supplies the force that turns the axles and wheels.

Machines with wheels and axles are Ferris wheels, gears, water taps, and hamster exercise wheels.

Sometimes an idea is so good, you just use it over and over again. That nice round wheel is one good idea. You see it used all over the place. The wheel and axle is only one simple machine that uses it. You'll see that round shape many more times in this module.

Turn to Assignment Booklet 1A and complete question 2 of the Section 1 Assignment.



Suggested Answers

Activity 2: Easy Roller

3. Pull the box across the table. What do you notice?

It is difficult to pull the box. It takes a lot of effort to pull the box.

5. Pull the box across the table. Explain the difference between pulling the box with and without the pencils.

It is much easier to pull the box when it is on rollers (the pencils).

Key Words

friction: a force that opposes the motion between two objects in contact with each other

theory: a general rule that explains or predicts facts or events

wheel and axle: a simple machine made up of an attached wheel and cylinder

Image Credits

Lesson 3: Pulley Power

Have you ever raised or lowered a window shade? You likely used another type of simple machine—the **pulley**. Pulleys make lifting easier. You raise something by pulling down on a line, instead of having to lift it up. Today you will examine how pulleys work. You will also make your own pulley.

pulley: a wheel-and-axle system used to change the direction of an applied force

Picture yourself on a sailboat. The wind is blowing, and it is time to raise the sails. How are you going to do it? Will you climb the mast, holding on to the end of the sail? Sails are heavy. That would be hard and dangerous work. There is an easier way.

A pulley has a rope, belt, or chain wrapped around a wheel and axle. How does a pulley work?

Try this simple activity:

1. Throw a rope over a tree branch. (If you do not have access to a tree, ask permission to use a door, shower rod, closet rod, or other suitable item.)

2. Tie a heavy object to one end of the rope. You could use a large book, a 2-kg bag of sugar, or something similar.

3. Pull on the other end of the rope.

The rope and tree branch work as a pulley. To lift the object, you pull down on the rope. Without the branch, you would have to lift the object up. Which would be harder? The machine—the pulley—has changed the direction of the force you use to lift the object.

A branch is not very smooth. There is a lot of friction between the rope and the branch. A wheel and axle can help reduce friction, making pulling easier. To make things safer, pulleys use a grooved wheel. The groove helps to keep the rope in place.

Can you see how a pulley would help you raise the sails in a sailboat? Lines work through several wheels and the top of the sail attaches to the end of one line. As you pull on the other end of the line, the sail rises.

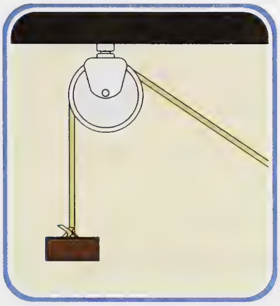
simple pulley: a pulley with one wheel

fixed pulley: a pulley attached to something that does not move

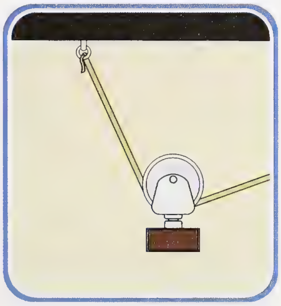
movable pulley: a pulley that moves with the load

load: object or material to be moved

A **simple pulley** is a pulley with one wheel. A **fixed pulley** is a pulley attached to something that does not move. It might attach to a ceiling or the mast of a sailboat. A **movable pulley** is a pulley attached to the thing you are lifting—the **load**.



Fixed Pulley



Movable Pulley

Fixed pulleys and movable pulleys both help you lift objects, but they do so in different ways.

Explore fixed and movable pulleys in the following activity.

Activity 3: Lifting the Easy Way

What you need

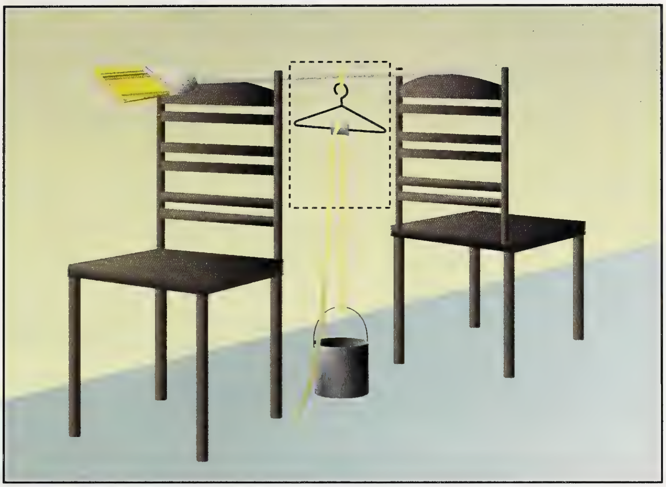
- a metal coat hanger
- 2 chairs
- a broom or dowel
- an empty spool from thread
- scissors
- 2 m heavy string, cord, or twine
- a plastic bucket with a sturdy handle
- stones, marbles, or other heavy objects
- a ruler
- duct tape or masking tape
- a felt marker
- pliers
- gloves (optional)

Note: You could use a sewing machine bobbin instead of the spool from thread.

What to do

Part A: Fixed Pulley System

Look at the diagram to help with this activity.



Have an adult help you unwind the wire around the neck of the metal hanger. The ends of the wire may be sharp.

1. Ask an adult to help you unwind the wire coiled around the neck of the hanger. Use the pliers. Wear gloves to help protect your hands.

2. Slip the spool over the end of the wire and position it in the middle of the hanger. Then tape the neck of the hanger back together.

3. Place the two chairs back to back and lay the broom across the top of the backs.

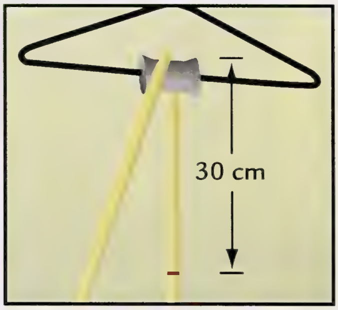
4. Tie a loop of rope around the broomstick and hang the hanger from it. (See the diagram at the beginning of this activity.)

   You could also simply suspend the hanger from the broomstick.

5. Cut a piece of string or cord about 1.5 m long and tie one end to the handle of the bucket. Loop the other end over the spool. Partly fill the bucket with stones, marbles, or other objects. Don't make it too heavy!

Ask your home instructor to help you do the measurements.

6. This is a fixed pulley. Measure 30 cm from the pulley toward the bucket. Mark this spot on the rope. Use a felt marker. Pull the rope downwards until the mark on the rope comes up to the pulley.



7. Measure how far the bucket lifted off the ground.

   Distance the bucket lifted off the ground: ______ cm

8. Now answer the following questions.

   a. In which direction did you apply the force to the rope—up or down?

   ____

   b. As you applied the force, in which direction did the load move?

   ____

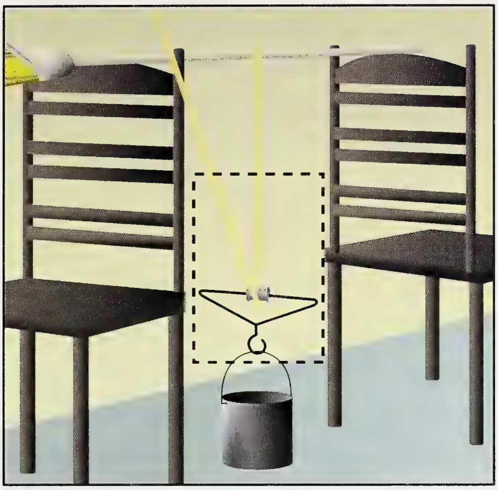
   c. When you pulled the rope, the load moved. Did the load move less, the same, or more than the distance you pulled the rope?

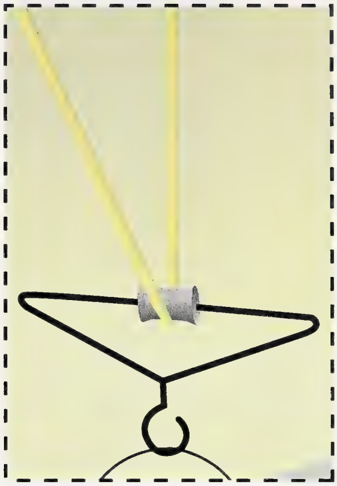
   ____

   ____

Part B: Movable Pulley System

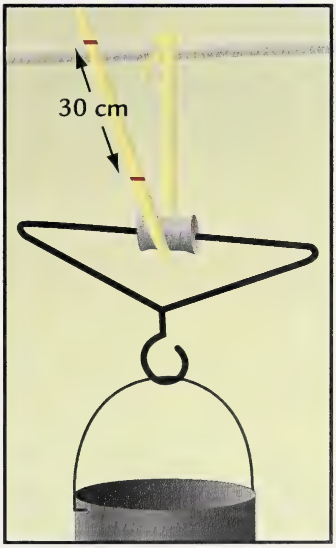
Look at the diagram to help with this activity.





9. Remove the short rope that attached the hanger to the broomstick.

10. Tie one end of the long rope to the broomstick. (See the diagram.)



11. Hang the bucket from the hook on the hanger and loop the rope under the spool. This is a movable pulley.

12. Hold the free end of the rope against the broomstick. Pull on the rope until the load just lifts from the floor. Use the felt marker to mark the rope at the top of the broomstick. Measure 30 cm down the rope and mark it there as well.

    Now pull the rope up until the second mark is at the top of the broomstick.

13. Measure how far the bucket has moved.

Distance the bucket moved: _____ cm

14. Now answer the following questions.

   a. In which direction did you apply the force to the rope—up or down?

   ____

   b. As you applied the force, in which direction did the load move?

   ____

   c. When you pulled the rope, the load moved. Did the load move less, the same, or more than the distance you pulled the rope?

   ____

   ____

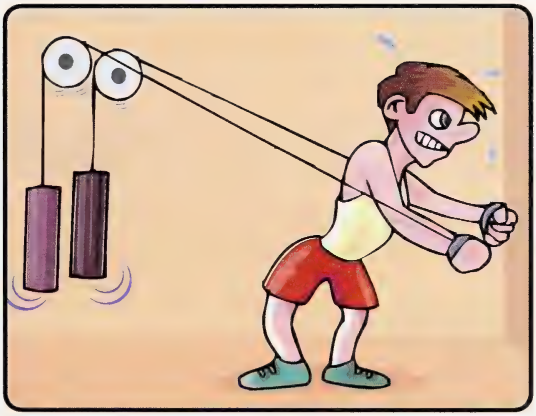
Note: Save the pulley you created in this activity. You will use it in Lesson 4.

Check your answers for this activity in the Suggested Answers at the end of this lesson.

You found that a fixed pulley changes the direction of the force needed to move an object. You can lift something by pulling down instead of lifting up. This seems easier because your body's weight helps you pull down. The load will move the same distance that you pull on the rope.

With a movable pulley, both ends of the rope support the load. The fixed end of the rope supports part of the load. This means that you support part of the load. You need less force, but you must move your end of the rope farther. You have to pull the rope twice the distance the load moves. So, to move the load 15 cm, you must pull the rope 30 cm.

In this lesson, you saw that pulleys are used in different ways. They can change the direction of force needed. They can change the amount of force needed–but at the cost of working longer. This is a lot like sharing a job with others. You each do a part of the work so it's easier.

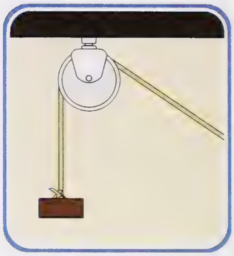


Turn to Assignment Booklet 1A and complete question 3 of the Section 1 Assignment.

Suggested Answers

Activity 3: Lifting the Easy Way

Part A: Fixed Pulley System



7. Measure how far the bucket lifted off the ground.

   Distance the bucket lifted off the ground: about 30 cm

8. a. In which direction did you apply the force to the rope—up or down?

      You pulled down on the rope.

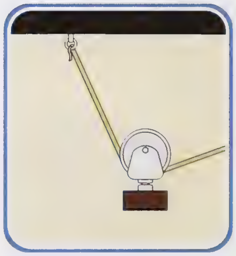
   b. As you applied the force, in which direction did the load move?

      The load moved up.

   c. When you pulled the rope, the load moved. Did the load move less, the same, or more than the distance you pulled the rope?

      The load moved 30 cm, the same distance the rope was pulled.

Part B: Movable Pulley System



13. Measure how far the bucket has moved.

    Distance the bucket moved: about 15 cm

14. a. In which direction did you apply force to the rope—up or down?

       You pulled the rope up.

    b. As you applied the force, in which direction did the load move?

       The load moved up.

c. When you pulled the rope, the load moved. Did the load move less, the same, or more than the distance you pulled the rope?

The load moved about 15 cm. This is about half as far as the rope was moved. The load moved less distance.

Key Words

fixed pulley: a pulley attached to something that does not move

load: object or material to be moved

movable pulley: a pulley that moves with the load

pulley: a wheel-and-axle system used to change the direction of an applied force

simple pulley: a pulley with one wheel

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Lesson 4: Complex Pulley Systems

If one pulley makes lifting easier, can adding more pulleys to a system help? Yes! Try using fixed and movable pulleys together. These **compound pulleys** make lifting even easier.

compound pulley: a pulley system with more than one wheel

Today you will explore compound pulleys. You will discover how the ropes divide the load so you use less force. You will also find out that you have to pull much more rope.

A Great Scientist

Leonardo da Vinci

Have you ever heard of the painting, the *Mona Lisa*? The Italian artist Leonardo da Vinci painted it. You can find a picture of the painting at this website.

http://www.ibiblio.org/wm/paint/auth/vinci/joconde/joconde.jpg

Leonardo da Vinci was also a great scientist, architect, musician, and inventor. He had a curious way of writing too. He used mirror writing to record his work. He wrote everything backwards. You'd have to hold it up to a mirror to read it!

Leonardo was born in 1452 in a small town called Vinci. He was a curious boy and loved to sketch. He was always studying the world around him. Once Leonardo visited a building site in Florence, Italy, and made careful drawings of all of the machines he saw.

Leonardo da Vinci loved inventing things. He designed machines such as alarm clocks, water wheels, and helicopters. He made them by putting together different simple machines—the same machines you have been studying in this module!

In the last lesson you found out that a fixed pulley changes the direction of a force. This makes lifting seem easier. In fact though, you use the same amount of force. You also saw that a movable pulley decreases the force needed. You just have to pull over a longer distance. What happens when you combine a fixed pulley and a movable pulley?

Activity 4: Combining Pulleys

What you need

- pliers
- a ruler
- scissors
- a felt marker
- an elastic band
- metal coat hanger
- duct tape or masking tape
- an empty spool from thread *
- 3 m heavy string, cord, or twine
- your fixed pulley system from Activity 3 **
- gloves (optional)

* or a sewing machine bobbin
** including the chairs, broom, and bucket

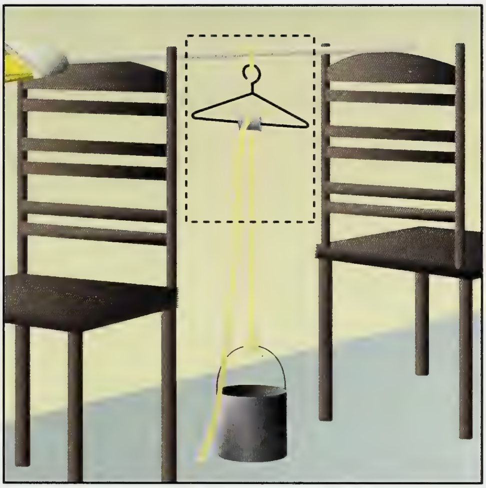
What to do

1. Fill in the blank with your prediction.

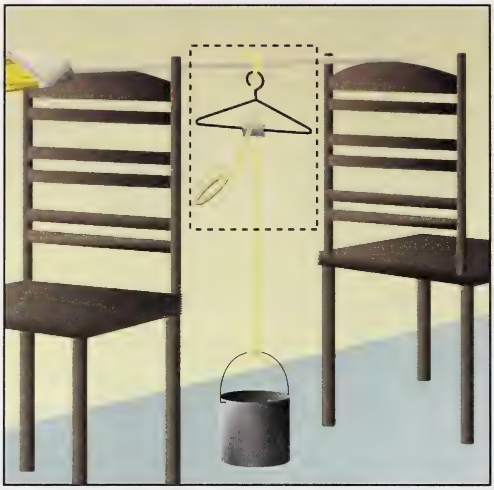
   I predict that to lift an object using a compound pulley system you will use ________________ (more, the same, less) force.

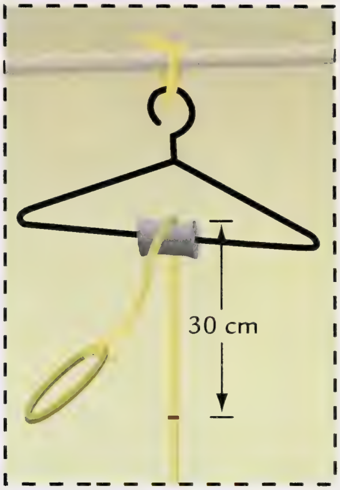
2. Set up a fixed pulley as you did in Part A, Activity 3: Lifting the Easy Way.

   Your set-up will look like the following diagram. (You could hook the hanger directly on the broomstick.)



3. Attach an elastic band to the end of the rope you will be pulling. Tie the end of the rope firmly to the elastic band.





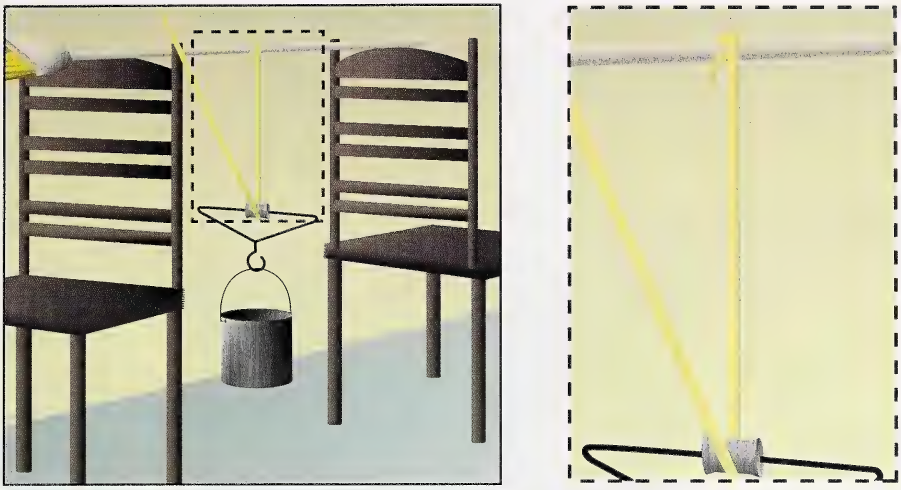
Ask your home instructor to help you do the measurements.

4. Mark the rope 30 cm from the top of the pulley. Use the felt pen. Pull the elastic until the mark on the rope is at the top of the pulley.

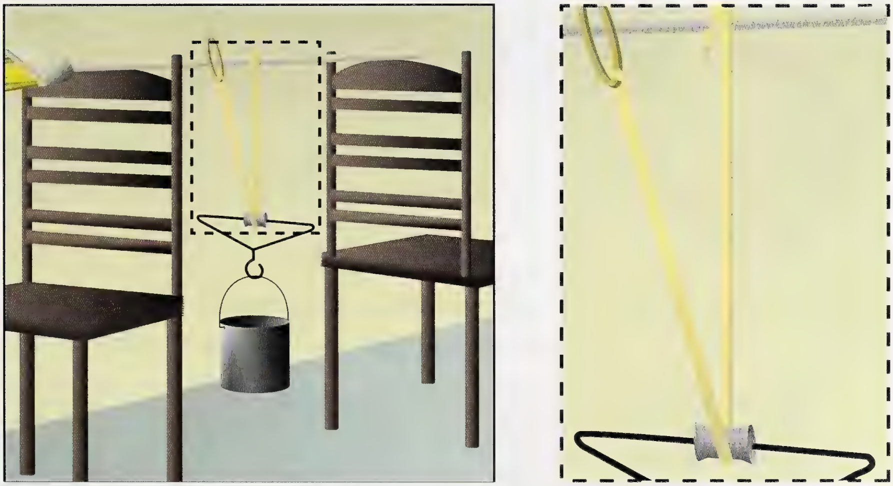
5. Measure how much the elastic stretches. Also measure how high the load lifts off the floor. Record these results for the fixed pulley in boxes **a.** and **b.** in the chart.

Pulley Type	Length of Elastic (cm)	Height Load Lifted (cm)
fixed	**a.**	**b.**
movable	**c.**	**d.**
compound	**e.**	**f.**

6. Set up a movable pulley as you did in Part B, Activity 3: Lifting the Easy Way. Your set-up will look like the following diagram.



7. Attach an elastic band to the rope you will pull. Tie the end of the rope firmly to the elastic band. Pull the elastic so the rope moves 30 cm. Mark the rope as you did in Activity 3, Step 12.



8. Measure how much the elastic stretches. Also measure how high the load lifts off the floor. Record these results for the movable pulley in boxes **c.** and **d.** in the chart.

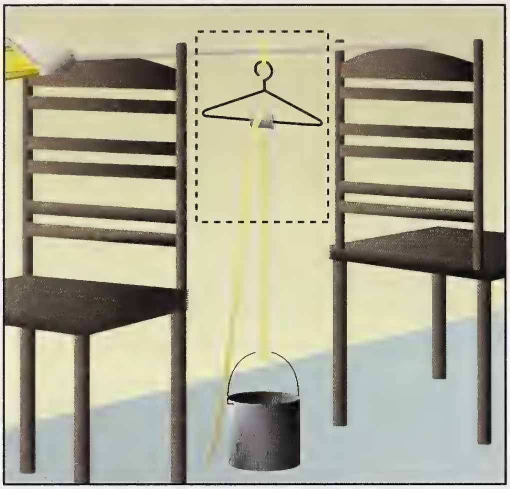
Home Instructor

9. Have an adult help you make another pulley. Follow the instructions given in steps 1 and 2 of Part A, Activity 3.

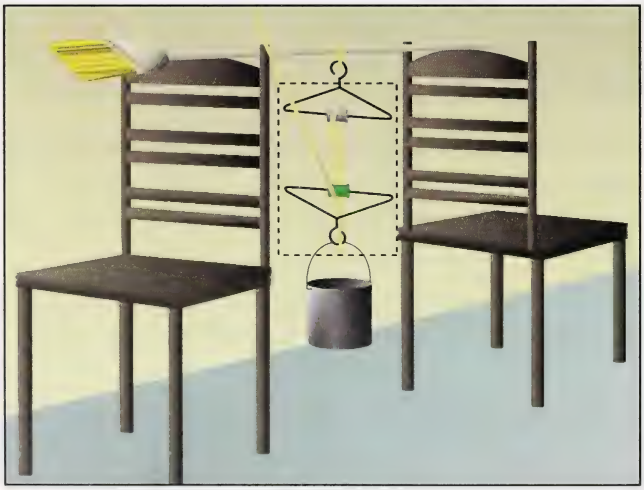
CAUTION: Have an adult help you unwind the wire around the neck of the metal hanger. The ends of the wire may be sharp.

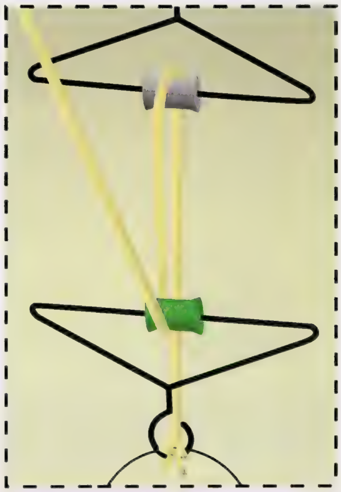
10. Attach the new pulley to the broom handle. Tie a loop of rope around the broomstick and hang the hanger from it. It is a fixed pulley (like the one used in Step 2).

11. Attach one end of the long rope to the bucket handle. Loop the rope around the fixed pulley.



12. Now hook the second coat hanger to the handle of the bucket. (The hanger hook will be near the knotted end of the rope on the pail handle.) Then loop the loose end of the rope around the pulley on the second coat hanger (the rope will go under the second pulley). This is a compound pulley. Your set-up should now look like this.





13. Attach the elastic band to the end of the rope you will pull. Pull the elastic until the rope moves 30 cm. (Use the same measuring method as in Activity 3. Ask your home instructor for help with this step.)

14. Measure how much the elastic band stretches. Also measure how high the load lifts off the floor. Record these results for the compound pulley in boxes **e.** and **f.** in the chart.

15. Is there an advantage to using a compound pulley system? Give a reason for your answer.

____

____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

block and tackle: a type of compound pulley

A **block and tackle** is one type of compound pulley system. You will find these systems used in many situations. In crab fishing, for instance, a block and tackle pulls traps out of the water.

When you combine pulleys, you have more sections of rope in the pulley system. The ropes share the weight of the load. Think of it this way:

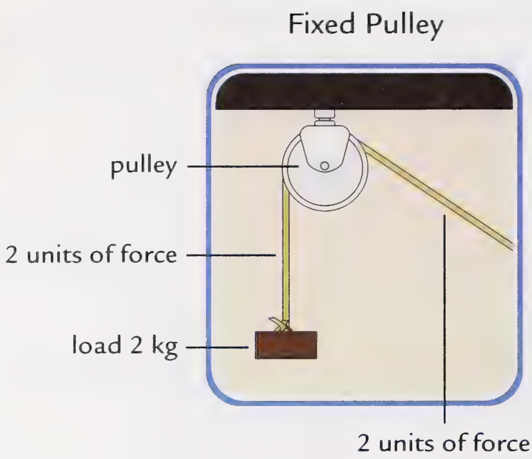
more rope sections

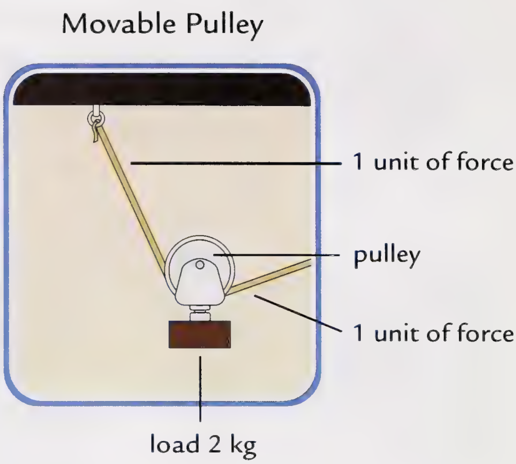
↓

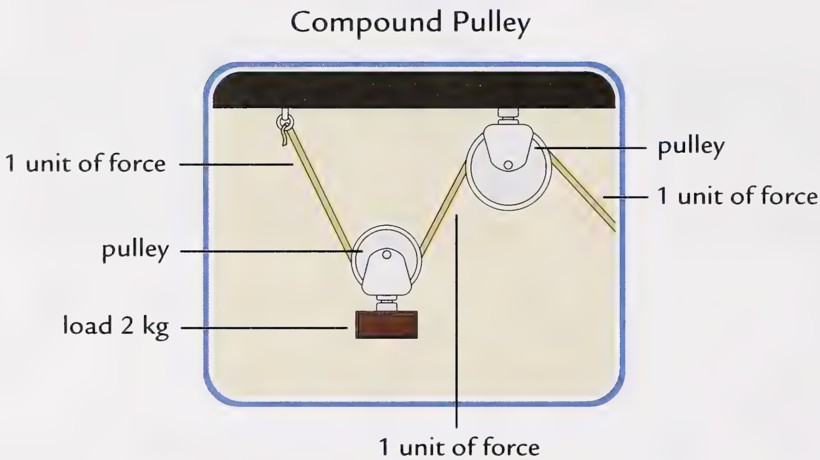
less load on each section

↓

less force needed to lift



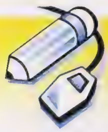




The ropes divide the load so you use less force. However, you will have to pull much more rope.

You can play with virtual pulleys at the Physics Zone's Pulley System page.

http://www.sciencejoywagon.com/physicszone/lesson/otherpub/wfendt/pulleysystem.htm



Turn to Assignment Booklet 1A and complete question 4 of the Section 1 Assignment.

Suggested Answers

Activity 4: Combining Pulleys

1. Fill in the blank with your prediction.

I predict that to lift an object using a compound pulley system you will use **less** force.

5., 8., and 14. Measure how much the elastic stretches. Also measure how high the load lifts off the floor.

Answers will vary. The length of the elastic will depend on the elastic and the weight of the bucket. The length of the elastic in the compound pulley should be the shortest (the compound pulley needs the least force). The length of the elastic in the fixed pulley should be the longest (the fixed pulley needs the most force). Look at these sample answers.

Pulley Type	Length of Elastic (cm)	Height Load Lifted (cm)
fixed	**a.** longest stretch	**b.** about 30 cm
movable	**c.** medium stretch	**d.** about 15 cm
compound	**e.** shortest stretch	**f.** about 10 cm

15. Is there an advantage to using a compound pulley system? Give a reason for your answer.

Yes, there is an advantage to using a compound pulley system. Each section of rope supports part of the load. The more sections there are, the less load each one has to support. This means moving the weight also takes less force. However, you will have to pull much more rope.

Key Words

block and tackle: a type of compound pulley

compound pulley: a pulley system with more than one wheel

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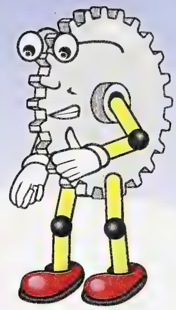
Section 1

Conclusion



Now you know how you can use simple machines to make everyday tasks easier. In this section, you explored inclined planes, wheel-and-axle devices, and pulleys.

You also experimented making your own simple machines. Great job!

How many simple machines can you find in the picture?

Now turn to Assignment Booklet 1A and complete the Student Feedback questions. Then go to the Checklist for Section 1. Make sure you have collected everything on the Checklist to send to your teacher. Also, if you like, choose one of the optional follow-up activities to send in as well.

Optional Follow-up Activities

Activity 1: Ancient Machines

How did the Egyptians build the pyramids without modern machines?

Do some research in the library or on the Internet. See how ancient Egyptians used simple machines to build structures as amazing as the Pyramids.

Activity 2: Pulley Power

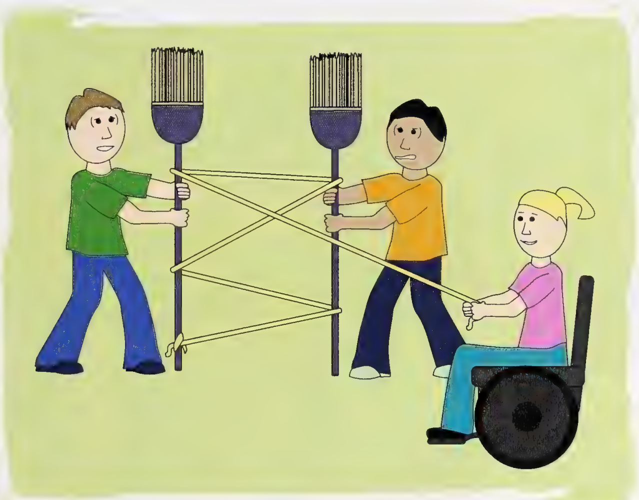
What you need

- 2 brooms
- a long rope

What to do

Amaze your friends with your super strength (and your knowledge of pulleys) by performing this trick.

Have two friends each hold a broom about 50 cm apart. Tie one end of a rope to one of the broom handles and wrap the remaining rope around the two brooms as shown.



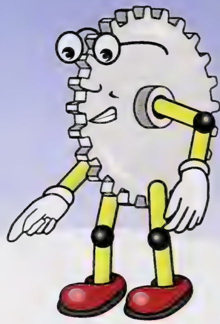
Challenge your friends to keep the brooms apart while you pull on the loose end of the rope.

Who is stronger? How did the simple machine help you?

Section 2

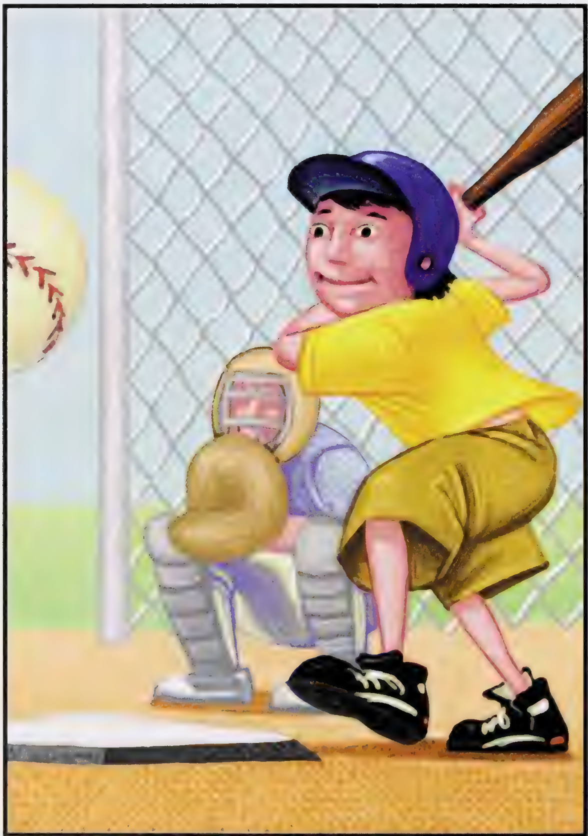
Levers

Introduction



In Section 1, you explored some simple machines that make our lives easier.

In Section 2, you will look at levers, another simple machine that is all around us. You may be surprised to find that you use levers every day!



Lesson 5: Lifting with Levers

Have you ever played on a teeter-totter, hit a baseball, or used a fishing rod? If you have, you have used another simple machine called a **lever**. Levers can decrease the force necessary to do a task so you can do things more easily. Levers can also increase the force needed, but make the object move faster. Today you will experiment with levers.

lever: a stiff bar or rod that pivots around a fixed point

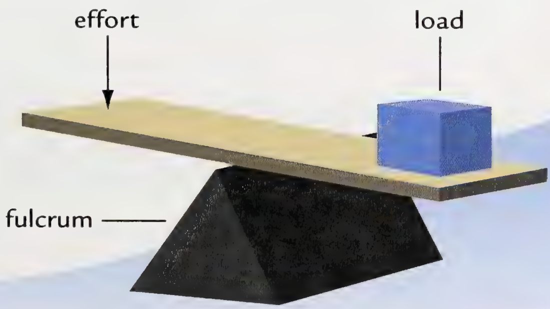
A lever is a stiff bar, rod, or even a board, that **pivots**, or moves, about a **fixed** point. This fixed point is the **fulcrum**.

pivot: to move around a fixed point

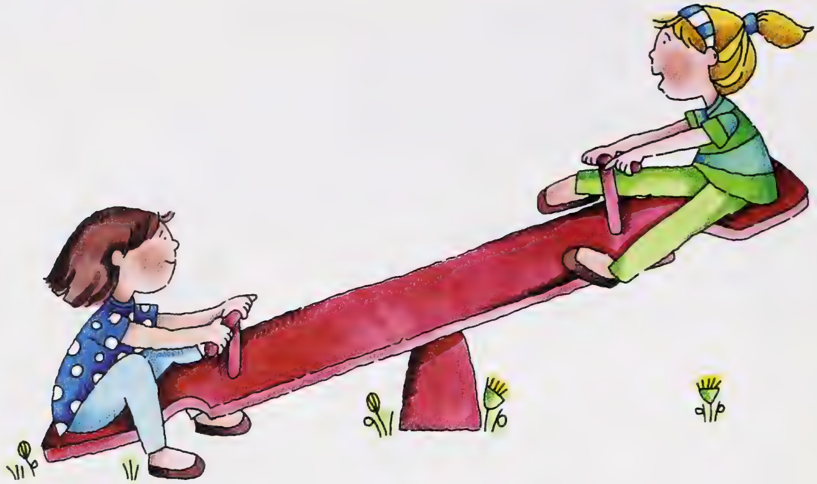
fixed: does not move

fulcrum: fixed point on a lever

In a teeter-totter, the fulcrum is the bar on which the teeter-totter balances.



A lever works by changing the direction of a force. Suppose you are playing on a teeter-totter with a friend. You push down with your feet and go up while your friend comes down.



A lever also allows people to move very large objects, such as boulders, that they could not move without a lever. In Activity 5, you will try lifting a book using a ruler as a lever. Give it a try and have fun.

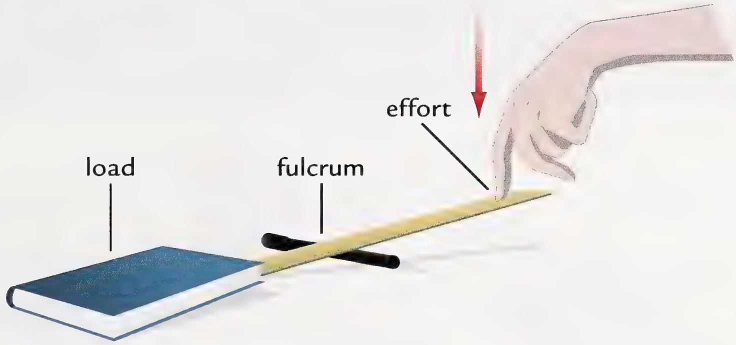
Activity 5: Lifting Loads

What you need

- a 30-cm ruler
- a metre-stick (or similar length stick)
- a fat felt pen or similar object to use as a fulcrum
- 3 books of different weights (light, medium, heavy)

What to do

1. Slide one end of the 30-cm ruler under the lightest book. Place the fulcrum (the pen) 5 cm to 10 cm from the book. Push down on the other end of the ruler. This will lift the book.



2. Repeat Step 1 using the metre-stick.

3. Repeat Step 1 and Step 2 with the medium-weight book and heavy book.

4. Which ruler made it easier to raise the books—the long or short ruler?

____

5. Was your answer the same for all of the books? Explain why or why not.

____

____

____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

In Activity 5, the pen is the fulcrum. The load is the object (the book) you are trying to lift or move. The effort is the force you apply to the lever. You need to know these terms to discuss levers and other simple machines.

How much can you lift with a lever? Levers have been used for thousands of years. The famous Greek thinker Archimedes studied levers. He knew the mathematics behind levers and declared, "With a lever long enough and a point to stand upon, I could move the world." Now that is a heavy load!

You can test what you discovered about levers at this website.

http://sunshine.chpc.utah.edu/javalabs/java12/machine/act1/lab2.htm

Turn to Assignment Booklet 1B and complete question 5 of the Section 2 Assignment.

Suggested Answers

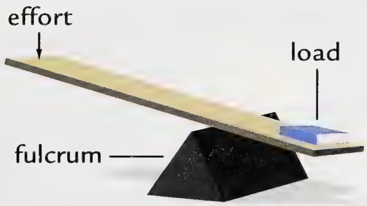
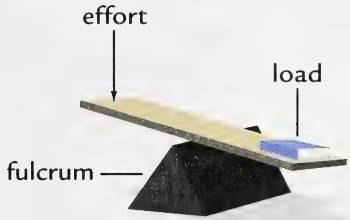
Activity 5: Lifting Loads

4. Which ruler made it easier to raise the books—the long or short ruler?

The short ruler needed more effort. Using the longer ruler was easier.

5. Was your answer the same for all of the books? Explain why or why not.

Yes, the answer was the same for all of the books. The distance from the load (the books) to the fulcrum (the pen) was about the same in all cases. The distance from the effort to the fulcrum was much greater with the metre-stick. This was true for all three books.

longer distance from effort to fulcrum—less effort	shorter distance from effort to fulcrum—more effort
	

Key Words

fixed: does not move

fulcrum: fixed point on a lever

lever: a stiff bar or rod that pivots around a fixed point

pivot: to move around a fixed point

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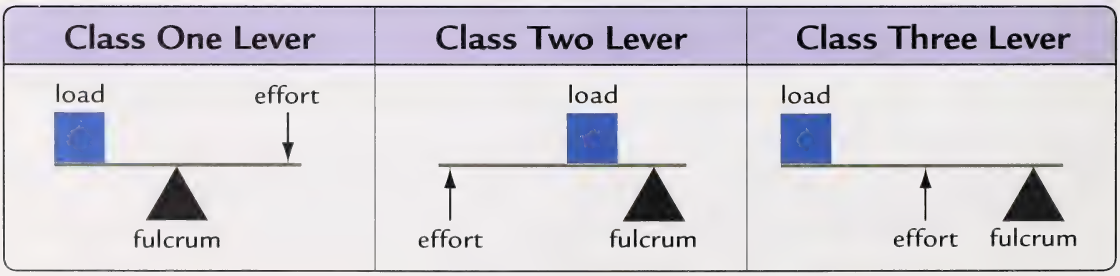
Lesson 6: Types of Levers

You'll find different kinds of levers all around you. Did you know that a wheelbarrow is a type of lever?

There are three types or classes of levers. The following diagrams show these three classes of levers. Look closely at the position of the fulcrum, the load, and the effort in each type. Can you think of an example of each class of lever?



Classes of Levers

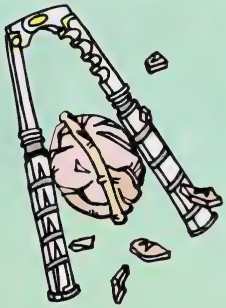
Following are examples of the three classes of levers. Did you think of any of these examples?

Class One Levers

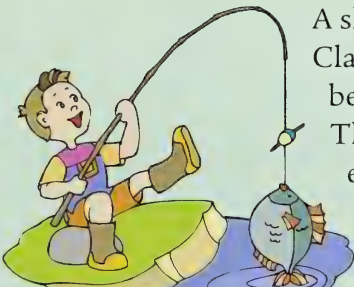
A crowbar and a teeter-totter are Class One levers. The fulcrum is between the effort and the load.

Class Two Levers

A wheelbarrow, doors, and nutcrackers are Class Two levers. The load is between the effort and the fulcrum. You apply effort at the ends of the handles. The load is between you and the wheel or joining point.



Class Three Levers



A shovel and a fishing rod are a Class Three levers. You apply effort between the fulcrum and the load. The fulcrum is your hand at the end of the shovel or rod. The effort is your other hand in the middle of the shovel handle or rod. The load is the dirt, sand, fish, or snow you are lifting.

There are levers in your body as well. Take "A Closer Look" at some of these levers.

A CLOSER LOOK

The Levers in You

Do these simple exercises. Each one shows a different class of lever.

1. Sit down and let your head lean forward. Now lift your head up straight. You have just used one of your body's Class One levers.

    - fulcrum (joints of the backbone)
    - load (weight of the head)
    - applied force (muscles in the back of the neck)

2. Stand up with your heels on the floor. Now stand on your tiptoes. You have just used a Class Two lever.

    - fulcrum (the ball of your foot)
    - load (your weight applied to the ankle joint)
    - applied force (calf muscle through Achilles tendon)

    The Achilles tendon attaches the calf muscle to the heel bone.

3. Stand with your arm straight down at your side. Put a heavy book in your hand. Bend your arm upward at the elbow. You have just exercised a Class Three lever.

    - fulcrum (your elbow)
    - applied force (biceps to forearm bones)
    - load (the book in your hand)

    The biceps is the large muscle at the front of your upper arm.

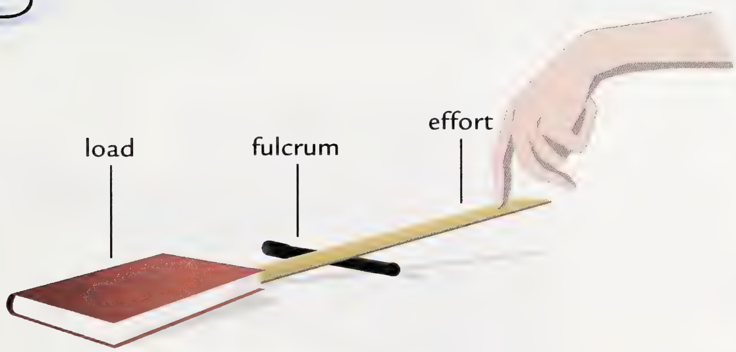
    When scientists build human-made arms, they copy the levers in a human arm. Doctors can connect tiny wires from the human-made arm to the nerves from the person's arm. These wires carry signals from the person's brain to the human-made arm.

As you have seen, levers can have the fulcrum, or fixed point, in different positions. The position of the fulcrum affects the way a lever works. You will move the fulcrum in the following activity with a Class One lever.

Activity 6: Moving Fulcrums

What you need

- a 30-cm ruler
- a heavy book
- a fat felt pen or similar object to use as a fulcrum



What to do

1. Slip one end of the ruler under the book. Place the fulcrum (the pen) about 10 cm from the book. Use the lever to lift the book. Feel how much force you use. Notice how high the book rises. Be ready to compare the effort and height with the other tests in Step 2.

2. Place the fulcrum about 15 cm from the book. Use the lever to lift the book.

   Now place the fulcrum about 20 cm from the book. Use the lever to lift the book.

3. Compare the amount of force you used in each step. Does moving the fulcrum affect how easy it is to lift the book?

4. Compare how high the book rose in each step. Does moving the fulcrum affect how high the book is lifted?

Check your answers for this activity in the Suggested Answers at the end of this lesson.

You've moved the effort, load, and fulcrum around. Did it surprise you that moving them around changed the work a lever does?

Speed things up, make it easier, move it a long way—all things levers can do for you.

Turn to Assignment Booklet 1B and complete question 6 of the Section 2 Assignment.

Suggested Answers

Activity 6: Moving Fulcrums

3. Compare the amount of force you used in each step. Does moving the fulcrum affect how easy it is to lift the book?

When the fulcrum moved farther away from the book, lifting became harder. Where you place the fulcrum changes how hard it is to lift the book.

4. Compare how high the book rose in each step. Does moving the fulcrum affect how high the book is lifted?

When the fulcrum moved farther away from the book, the book rose higher. Where you place the fulcrum changes how high the book is lifted.

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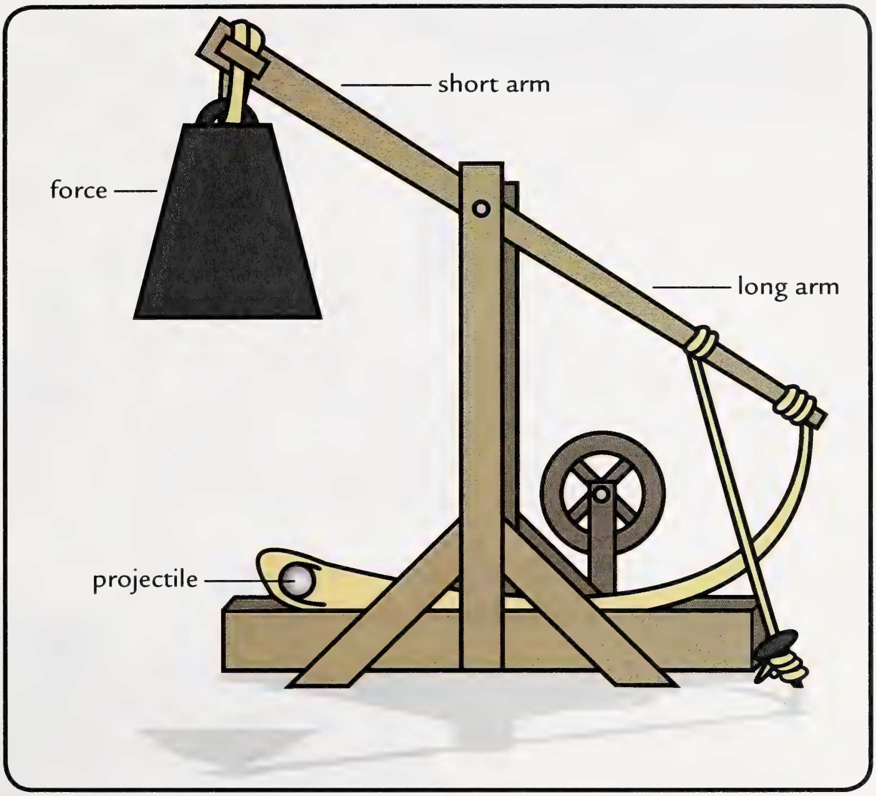
Lesson 7: A Medieval Lever

In medieval days (about A.D. 500 to A.D. 1500), the weapons people used were not our modern ones. If attackers wanted to capture a castle, it was really hard. How could they break down the stone walls of the castle? They used large boulders thrown with a great deal of force. People were not strong enough to lift the boulders. They certainly couldn't throw them with any force. So what did they do?

In the lessons of this module, you've looked at many simple machines. The machines help you by making chores easier. Many of these machines have been used for a very long time. How were the Great Pyramids of Egypt built? Many scientists think that ramps, rollers, and pulleys were used to move the rocks into position.

trebuchet: a medieval military machine for throwing heavy missiles (such as rocks)

In medieval days, a weapon called a **trebuchet** was developed. This giant machine was more than a simple lever. With it, attackers could apply a huge force and throw heavy things at castle walls. (Stories from this time say some castle owners gave up as soon as they saw the trebuchet.)

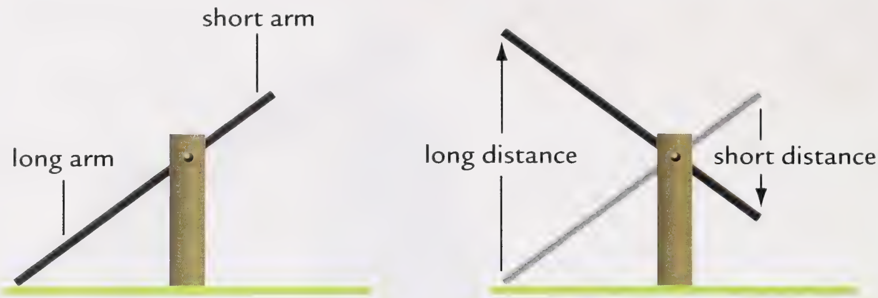


A trebuchet was used like this:

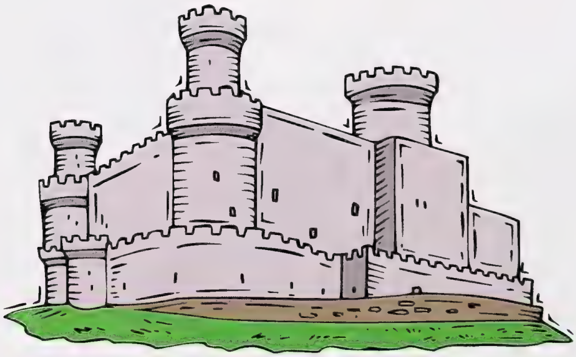
- Fasten the long arm of a lever to the ground.
- Attach a sling to the long end of the lever.
- Put a boulder (a **projectile**) in the sling.
- Attach a large weight to the short end of the lever.
- Release the long arm of the lever.
- Let the large weight fall.
- The long arm of the lever lifts very quickly.
- The boulder in the sling also moves very quickly.
- The boulder flies to its target.

projectile: an object; such as a rock, that is thrown (often as a weapon)

A trebuchet uses the speed-increasing action of a lever. Look at these diagrams. What happens when the short arm moves down? It moves a short distance. At the same time, the long arm also moves. It moves a much longer distance. Its tip has to move much faster to travel the longer distance in the same time.



A trebuchet is very complex. Real trebuchets are very large. They have gears and ropes to tie the arms in position until ready to fire. Often the projectiles were rocks, but they could also be anything else that the attackers thought would help them take the castle.



Internet Link

You can discover more at this website.

http://www.wonderville.ca/v1/activities/levers/levers.html

Activity 7: How Far Does It Go?

In this activity,
you will build a simple
version of a trebuchet.

What you need

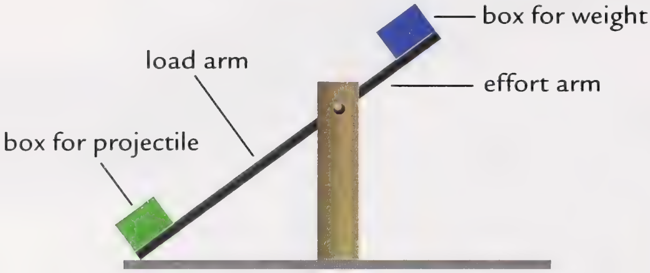
- a ruler, or similar flat piece of wood, for the arm (about 30 cm long)
- a base (a triangular piece of wood, building blocks, CD cases taped together, or anything else that allows the wood arm to move freely) Be sure the base is taller than the short arm to allow full movement.
- two small, light-weight, open boxes (one for the weights; one for the projectiles)
- a variety of projectiles (for example, coins, paper clips) Do not use sharp or breakable items.
- rubber bands or tape
- a variety of weights (for example, coins, marbles)
- a second ruler, metre-stick, or tape measure
- a kitchen scale (optional, but recommended)

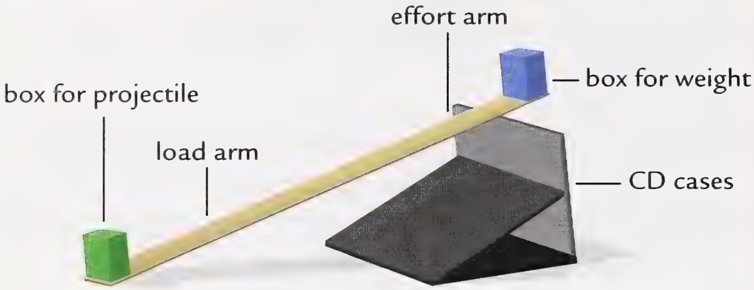
If you don't have a scale, here are the masses of Canadian coins. You can use them for comparison.

– dime	1.75 g	– quarter	4.4 g
– penny	2.35 g	– loonie	7.0 g
– nickel	3.95 g	– toonie	7.3 g

What to do

1. Build your trebuchet. It should be similar to the ones shown.





The way the CD cases are put together is important. To let the large weight fall as far as possible, one of the cases must be nearly vertical. The cases cannot be in a triangular shape or the weight hits the case before the projectile can be flung forward.

Use tape or rubber bands to fasten the boxes at the ends of the lever. The boxes keep the weights and projectile in place.

2. **a.** Draw your machine here. Label the load arm, effort arm, the box for the projectile, and the box for the weight.

b. Describe the materials you used in your design.

____

____

3. You will record your data in the chart given in Step 5. Review the columns to see what measurements you will be taking.

Use these steps to throw the projectile. Be sure you, other people, and any pets stay out of the way of your projectile. Respect other items in your home too. Do not use sharp or breakable objects.

Ask your home instructor to help you with this step.

- Move the rubber bands on the ruler to sit on each side of the fulcrum (this will stop the ruler from sliding). Measure the lengths of the effort arm and load arm.

- Find the mass of the weight. Place the weight in the box on the effort arm of the lever.

- Find the mass of the projectile. Place the projectile in the box on the load arm of the lever.

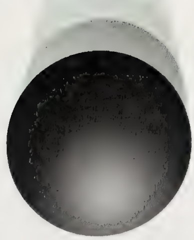
- Push the load arm down and hold it down. Make sure there is nothing and no one in the path the projectile will take.

- Release the load arm.

- Measure how far the projectile flies.

4. Try changing the following:

- the lengths of the load and effort arms
- the mass of the projectile
- the mass used on the effort arm



Make your design different by changing one thing at a time. Use a new row in the chart for each change.

5. Record your data in the following chart.

Length of the Effort Arm (cm)	Length of the Load Arm (cm)	Mass on the Effort Arm (g)	Mass of the Projectile (g)	Distance Projectile Travelled (cm)

6. Use your data from the chart in Step 5 to help you answer this question. In each part there are blanks in the table. Fill in the spaces using the given words.

   a. Use the words **long**, **medium**, and **short**.

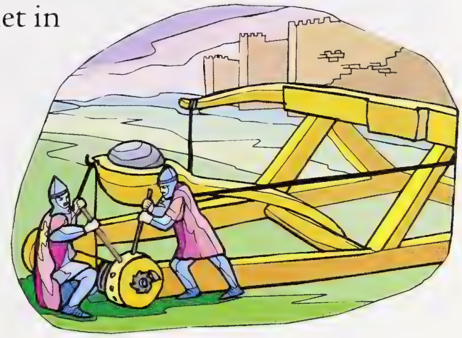
Length of the Effort Arm (cm)	Length of the Load Arm (cm)	Mass on the Effort Arm (g)	Mass of the Projectile (g)	Distance Projectile Travelled (cm)
10	20	100	2	
8	22	100	2	
5	25	100	2	

b. Use the words **heavy**, **medium**, and **light**.

Length of the Effort Arm (cm)	Length of the Load Arm (cm)	Mass on the Effort Arm (g)	Mass of the Projectile (g)	Distance Projectile Travelled (cm)
7	23		4.4	25
7	23		4.4	38
7	23		4.4	50

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Would you like to see a trebuchet in action? Go to the SciQ website. Click on QZones. Then, under Physics, click on Medieval Lever Activity. You can start the activity by clicking on Launch.



http://www.sciq.ca/

To discover even more about trebuchets, go to the following website. You can try your design skills in the activity "Destroy the Castle."

http://www.pbs.org/wgbh/nova/lostempires/trebuchet/

Turn to Assignment Booklet 1B and complete question 7 of the Section 2 Assignment.

Suggested Answers

Activity 7: How Far Does It Go?

Discuss any design problems with your home instructor.

2. a. Draw your machine here. Label the load arm, effort arm, the box for the projectile, and the box for the weight.

   Answers will vary. The diagram of your trebuchet should be similar to the ones shown in Step 1 of Activity 7.

   b. Describe the materials you used in your design.

   Answers will vary. Your materials may have been similar to the ones given in the activity. Perhaps you were able to design a trebuchet using very different materials. Did you have any difficulty finding suitable materials for your trebuchet? Perhaps your first design did not work well. Mention any changes you had to make.

5. Record your data in the following chart.

   Answers will vary. Your home instructor helped you with this step. It is very important to remember to change only one thing at a time–the lengths of the load and effort arms **or** the mass of the projectile **or** the mass on the effort arm.

6. Use your data from the chart in Step 5 to help you answer this question. In each part there are blanks in the table. Fill in the spaces using the given words.

   a. Use the words **long**, **medium**, and **short**.

Length of the Effort Arm (cm)	Length of the Load Arm (cm)	Mass on the Effort Arm (g)	Mass of the Projectile (g)	Distance Projectile Travelled (cm)
10	20	100	2	short
8	22	100	2	medium
5	25	100	2	long

b. Use the words **heavy**, **medium**, and **light**.

Length of the Effort Arm (cm)	Length of the Load Arm (cm)	Mass on the Effort Arm (g)	Mass of the Projectile (g)	Distance Projectile Travelled (cm)
7	23	light	4.4	25
7	23	medium	4.4	38
7	23	heavy	4.4	50

Key Words

projectile: an object, such as a rock, that is thrown (often as a weapon)

trebuchet: a medieval military machine for throwing heavy missiles (such as rocks)

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Lesson 8: Simple Machines Around You

In Lesson 7, you looked back in time at an early machine. Today, you will look around you to find modern uses of simple machines.

The Lever

You should be able to see many levers around you. Hammers, wrenches, golf clubs, and hockey sticks are levers. In the garden, a shovel and digging fork are levers. Nutcrackers, wire cutters, and scissors are pairs of levers joined together.

Levers were likely the first simple machines used. Does this surprise you?

The Inclined Plane

Did you climb some stairs today? If so, you walked up a simple machine.

The steps sit on top of an inclined plane. Look at the hand rail and you will see the slope of the inclined plane. If you put a board running from the top of the stairs to the bottom, you would have a ramp with the same slope as the hand rail.

Go to the kitchen sink and look at the draining board. The board slopes towards the sink so the water will run into the sink. This slope is an inclined plane. It is a very gentle slope, but without it the water would not drain away from your washed dishes.

Most bathtub bottoms and sinks also have a gentle inclined plane that slopes toward the drain.

The Wheel and Axle

What happens to a door handle when you turn it? Your force transfers from a wheel (the doorknob) to an axle (the shaft that goes through the door). You use this simple machine several times every day, without even thinking about it.

The volume control on an older radio, the steering column of a car, and the wheels on a bicycle are all examples of wheels and axles.

Does the tap on your bathroom sink use a wheel and axle? Often the tap handle turns an axle inside. The axle in a tap is also a type of screw, so this machine combines two different types of simple machines.

The Screw

Screws are a special kind of inclined plane. The sloping ridges wind around a central post. They are winding inclined planes. Farmers use augers (winding inclined planes) to lift their grain into storage bins. Augers can even lift water and snow. On construction sites, augers are used to drill holes for pilings (heavy steel beams or columns of concrete).

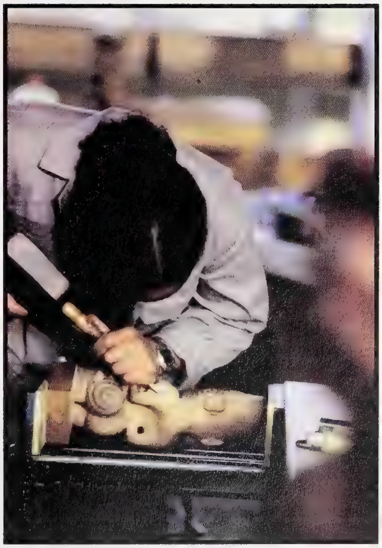
Screws hold together many of the things around you. Screws are not simply the small pieces of metal in a tool kit. They are often simple machines used to join things.

The end of a light bulb is a screw, and so are many jar tops with screw-on lids. When you twist a light bulb into a lamp or light fixture, you are really fitting two winding inclined planes together.

The Wedge

A wedge is two inclined planes joined together. Like inclined planes, wedges raise things up, or they cut through them. Have you ever seen a doorstop shaped like a wedge? The wedge slides under the door until it gets stuck. It holds the door open.

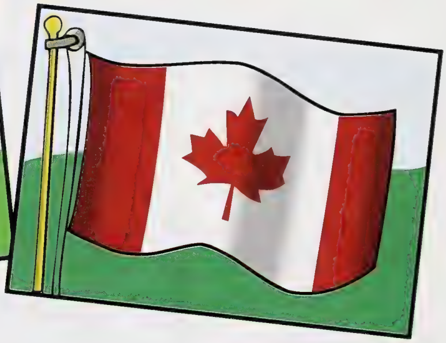
Some blocks of firewood don't split easily with a regular axe. A heavier wedge is used. You drive the wedge in with a sledgehammer. A wedge and sledgehammer are also used to split rocks and bricks.



Sculptors use wedges too. The wedge is on one end of a chisel (a cutting tool). The chisel is pushed by hand in soft material to carve out a shape. In harder materials, the chisel is pushed by a blow from a mallet or hammer.

The Pulley

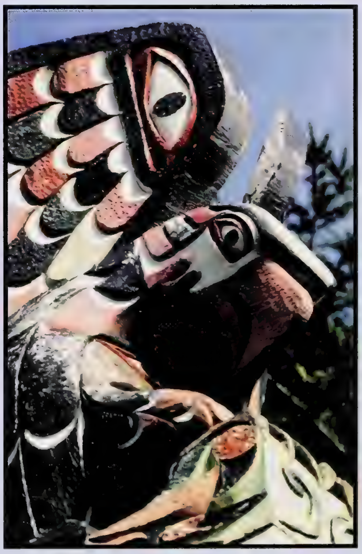
Have you ever ridden in an elevator? In many elevators a pulley system carries you up and down. There are many other simpler pulley systems around. Clotheslines are a loop of rope with a pulley at either end. Flagpoles have a pulley at the top. You often open curtains with a cord and a pulley.



Imagine

Aboriginal peoples on the west coast of Canada use simple machines to create and raise beautifully carved totem poles.

They carve these poles today in much the same way as they did hundreds of years ago. They use chisels made of metal. Long ago, these chisels would have been made of bone, shell, or stone. The huge poles were raised using levers and simple pulleys. Today, the poles are raised in the same way. Many people and a few simple machines are used just as they were hundreds of years ago.



A CLOSER LOOK

Leonardo da Vinci

You have already read about Leonardo da Vinci, who was a famous Italian artist and inventor. To discover about some of the inventions he made using simple machines, go to the Exploring Leonardo website.

Internet Link

http://www.mos.org/leonardo/

At this site you can peek into an inventor's toolbox by clicking on the Exploring Leonardo button. There are also activities to try.

You can also do a search using the words "Leonardo da Vinci" and "inventions."

Activity 8: Making Work Easy

How well do you know the simple machines? Do this activity to check your understanding.

What to do

For each object listed in the chart, tell what type of simple machine it is. Explain how you can tell what type of simple machine it is.

Remember the six simple machines:

- lever
- inclined plane
- wheel and axle
- screw
- wedge
- pulley

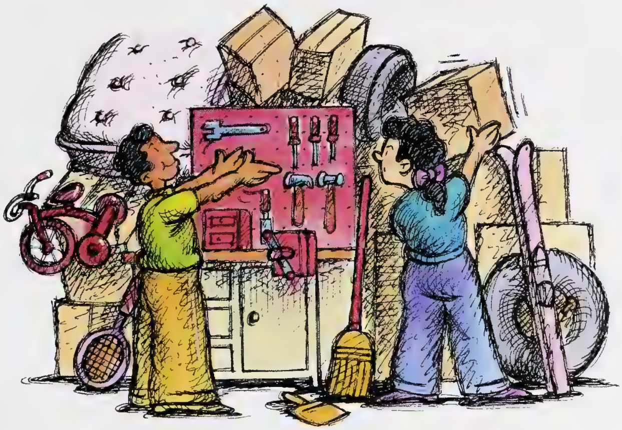
Object	Type of Simple Machine	How does it work?
grain auger		
wheelchair ramp		
axe head		
wheelbarrow		
teeter-totter		
curtain pull cord		
roller blades		

Check your answers for this activity in the Suggested Answers at the end of this lesson.

Here's a website that will give you a fun review of machines.

http://www.edheads.org/activities/simple-machines/index.htm

You have discovered a lot about simple machines. You have seen that machines are all around you. What machines can you see in the picture?



Turn to Assignment Booklet 1B and complete question 8 of the Section 2 Assignment.

Suggested Answers

Activity 8: Making Work Easy

For each object listed in the chart, tell what type of simple machine it is. Explain how you can tell what type of simple machine it is.

Remember the six simple machines:

- lever
- inclined plane
- wheel and axle
- screw
- wedge
- pulley

Answers are given in the chart on the following page. How well do you know your machines?

Object	Type of Simple Machine	How does it work?
grain auger	screw	It has an inclined plane winding around a central post.
wheelchair ramp	inclined plane	It allows wheelchairs to climb with less force or effort.
axe head	wedge	It is triangle-shaped, looking like two inclined planes back to back. It pushes things apart as it moves forward.
wheelbarrow	lever	It has a fulcrum (the wheel), and you lift a load by applying force on the handles.
teeter-totter	lever	It has a fulcrum (the middle), and you apply force at the ends to lift a load.
curtain pull cord	pulley	The cord goes around a grooved wheel. You pull down; the blind goes up. It changes the direction of the force.
roller blades	wheel and axle	The rollers are wheels with axles. You apply force to the wheels to move more easily.

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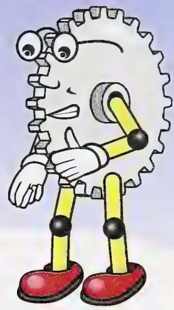
Section 2

Conclusion



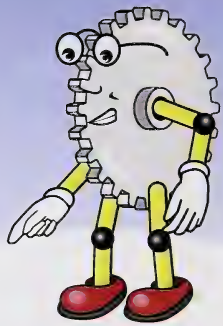
In this section, you studied one more simple machine, a lever. You have found levers in your environment. You also saw the three classes of levers.

You reviewed the types of simple machines you studied in Section 1. You experimented with an early machine called a trebuchet.

Section 3

Drive Systems

Introduction



Many complex machines move. They may move themselves from one place to another. They may help move other objects or people, or they may simply have moving parts. In this section, you are going to explore moving machines. You will even get the chance to build one!

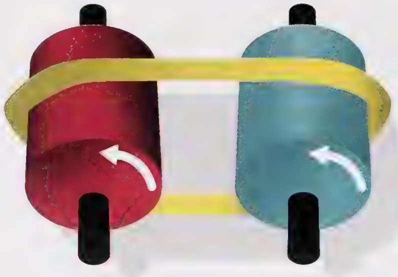
Lesson 9: Gears

complex machine: a machine made up of more than one simple machine

A machine made up of more than one simple machine is a **complex machine**. A bicycle is an example of a complex machine. It uses levers, screws, wedges, pulleys, and wheels and axles.

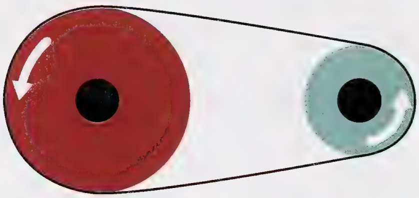
Moving vehicles are examples of complex machines. The system that drives them is also a complex machine. At the simplest, the drive system is two simple machines joined together. These two machines are the wheel and axle and the pulley.

How can you make two wheels turn together in the same direction?



You can join the wheels with a rope or belt in a single loop. This system combines wheels and axles and pulleys. This complex machine can drive a vehicle, such as a bicycle.

What happens if one of the wheels is bigger than the other?

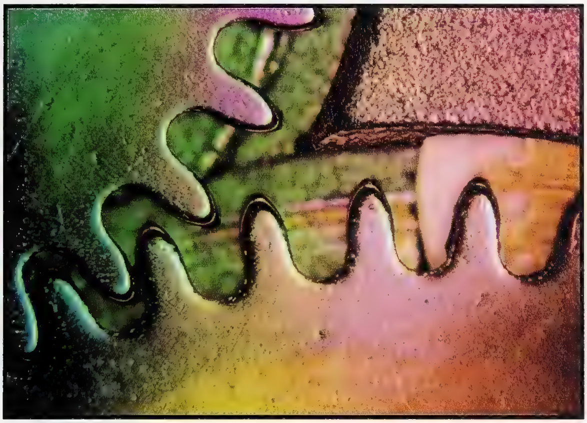


The bigger wheel will turn more slowly than the smaller one.

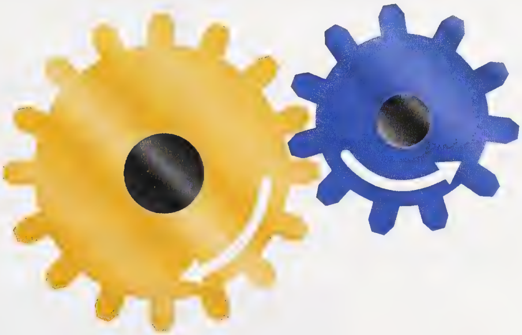
Another way to make wheels move together is to have them in direct contact with each other. However, smooth wheels may slip when they move.

If you put teeth on the edges of the wheel, they will not slip when they move. Wheels with teeth on their edges are called **gears**. Unlike the teeth in your mouth, these teeth must all be the same size. When two gears are connected, they turn in opposite directions.

gears: wheels with teeth on their edges



Gears help transfer movement and force from one place to another. Like wheels joined by belts or chains, large gears move more slowly than the smaller gears they connect to.



Changing speed has other effects too. Have you ever gone up a steep hill on a bike? Did you change gears to make it easier? There was a trade-off just like with inclined planes. Your feet had to travel farther, but it took a lot less effort.

Gears can also change the direction of the applied force.

horizontal: parallel to the ground

vertical: upright or straight up and down

Look at the following diagram. If you turn the **horizontal** axle, the pair of gears makes the **vertical** axle turn. You will discover more about this gear in Lesson 10.

When you combine pulleys and gears, you make a drive system. You are going to investigate drive systems in Activity 9.

Activity 9: Drive Systems

What you need

- a ruler
- 4 wheels *
- modelling clay (optional)
- sticky tape or masking tape
- 4 knitting needles or skewers **
- 3 elastic bands (in 3 colours, if possible) ***
- a pencil or felt marker (You will be marking the wheels.)
- a small empty box (such as a box from macaroni and cheese)

* Possible wheels are from LEGO®, MECCANO, K'NEX, or DUPLO® construction sets; spools from thread; empty camera film canisters with holes drilled into both ends; or sewing machine bobbins. Choose 2 wheels of the same size, 1 larger wheel, and 1 smaller wheel.

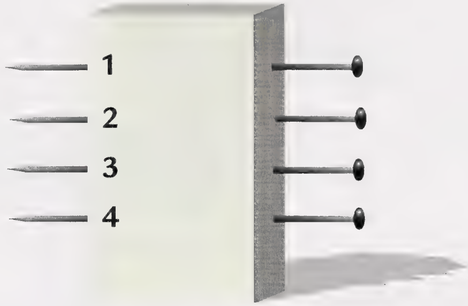
** The knitting needles or skewers must be small enough to fit into the axle holes in the wheels and long enough to go through the box and extend past both sides.

*** Elastic bands are readily available in bulk bags containing various colours and sizes. It may take some trial and error to find bands of the right size.

What to do

Have an adult help you poke the knitting needles or skewers into the box. It can be dangerous and might cause injury if they slip.

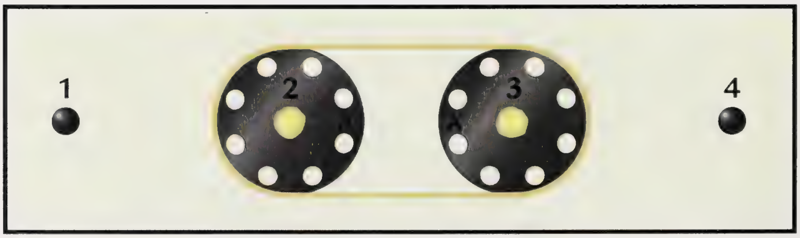
1. Poke the knitting needles through the box. Use the ruler to help you space the needles evenly. Make the needles go through the box completely. Label the needles 1, 2, 3, and 4.



2. Lay the box on its side near the edge of a table. Keep the sharp ends pointed up. Have the other ends of the knitting needles hang down over the edge. Tape the knitting needle ends to the edge of your table or counter top.

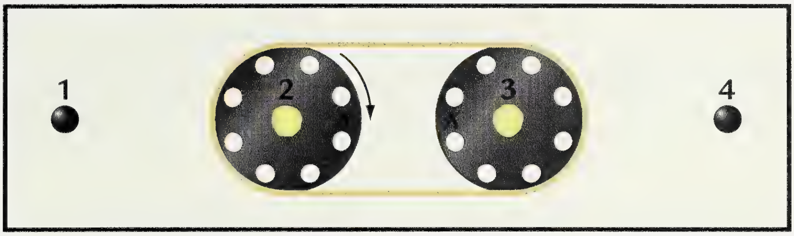
3. Choose the pair of wheels that are the same size. Put them on the two middle knitting needles (Needle 2 and Needle 3). Now make sure the wheels won't fall off. Put some modelling clay or tape on the sharp ends of the knitting needles.

4. Loop one of the elastic bands around wheels 2 and 3. When you look at the wheels from the top, they should look like this:



5. Mark the spot (on each wheel) with an X where the two wheels are closest to each other. (See the diagram.) These marks will let you see the direction and amount the wheels move.

6. Rotate the wheel on Needle 2 in a clockwise direction.



In which direction does the wheel on Needle 3 rotate?

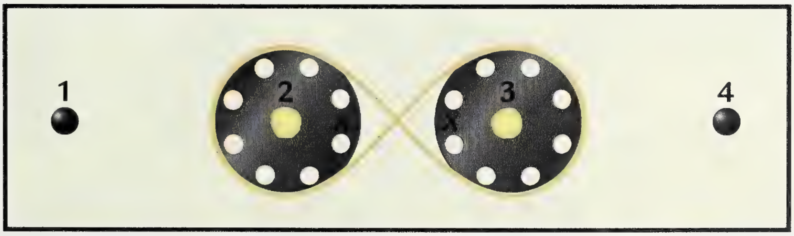
____

7. Rotate Wheel 2 one turn. How many turns does Wheel 3 rotate?

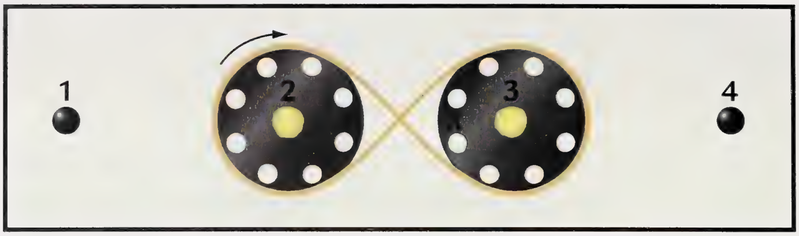
____

8. Take the elastic band off the two wheels. Now attach it in a "figure 8" around Wheel 2 and Wheel 3. Move the wheels so that the Xs are closest to each other.

When you look at the wheels from the top, they should look like this:



9. Rotate Wheel 2 in a clockwise direction.



In which direction does Wheel 3 rotate?

____

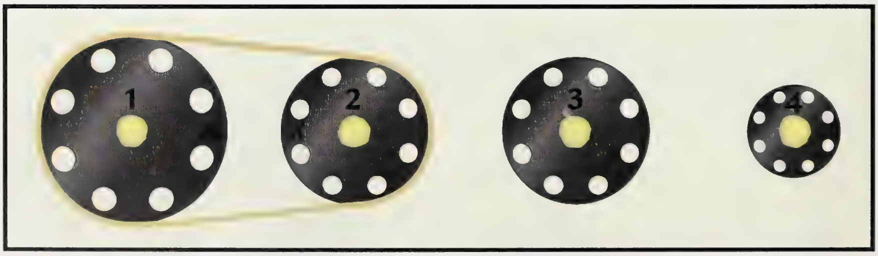
10. Rotate Wheel 2 one turn. How many turns does Wheel 3 rotate?

____

11. Place the larger wheel on Needle 1 and the smaller wheel on Needle 4. Make sure the wheels won't fall off. Put modelling clay or tape on the sharp ends of the knitting needles.

12. Take off the elastic band from wheels 2 and 3. Loop it around Wheel 1 and Wheel 2. Mark the spot (on each wheel) with an X where the two wheels are closest to one another.

When you look at the wheels from above, they should look like this:



13. Rotate Wheel 1 one turn. How many turns does Wheel 2 rotate?

____

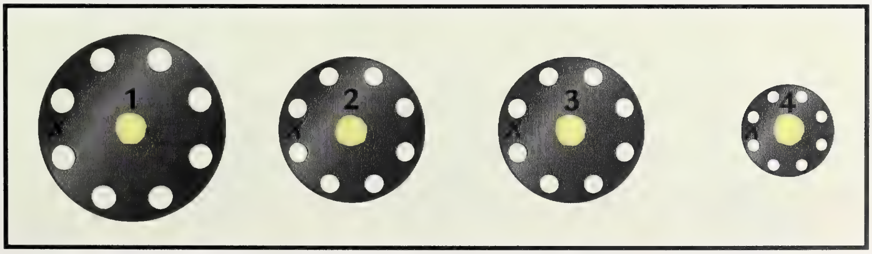
14. Now create your own drive system. Use all four wheels and three elastic bands. Use looped bands and "figure-8" bands. If possible, use a different colour elastic for each connection.

- One elastic band should connect Wheel 1 and Wheel 2.
- A second elastic band should connect Wheel 2 and Wheel 3.
- A third elastic band should connect Wheel 3 and Wheel 4.

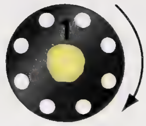
15. Sketch your drive system in the space below. Make your sketch to show your system from the top. Be sure to label wheels 1, 2, 3, and 4.

    Show the sizes of your wheels. Show how you placed the elastic bands. Use a different colour elastic for each connection.

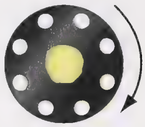
16. Mark Wheel 4 with an X. Adjust all of the wheels so that the Xs are pointed the same way. (**Note:** Your drive system may look different. This diagram shows one way of how the Xs should line up.)

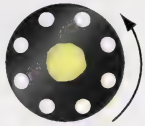


17. Do this step using your drive system. Rotate Wheel 1 in a clockwise direction. Watch the turning direction of the other wheels.



Are the wheels moving clockwise? or counterclockwise?





Wheel 2: ______________________________

Wheel 3: ______________________________

Wheel 4: ______________________________

18. Do this step using your drive system. Rotate Wheel 1 one full turn. Watch how much the other wheels turn.

   a. Which wheel moved the least?

   ____

   b. Which wheel moved the most?

   ____

Check your answers for this activity in the Suggested Answers at the end of this lesson.

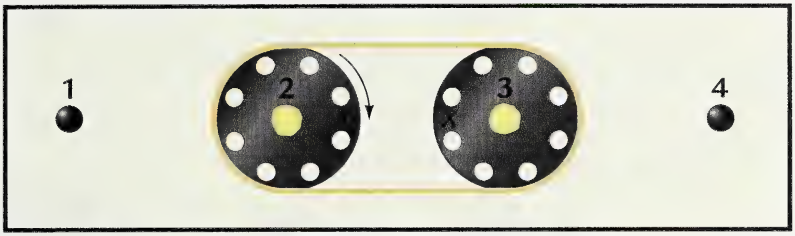
There are many examples of pulleys and gears in the machines around you. Friction toys, salad spinners, and some clocks all include gears to help them run.

Turn to Assignment Booklet 1B and complete question 9 of the Section 3 Assignment.

Suggested Answers

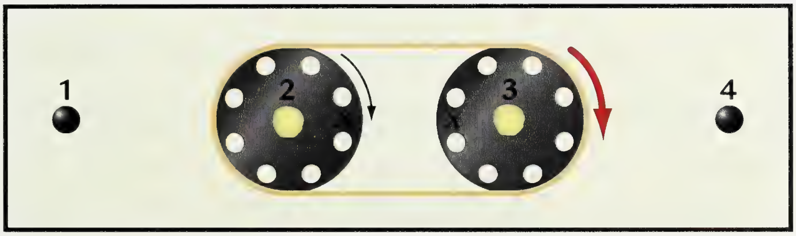
Activity 9: Drive Systems

6. Rotate the wheel on Needle 2 in a clockwise direction.



In which direction does the wheel on Needle 3 rotate?

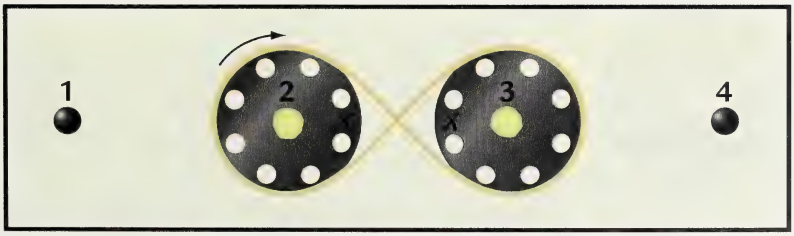
The wheel on Needle 3 also rotates in a clockwise direction.



7. Rotate Wheel 2 one turn. How many turns does Wheel 3 rotate?

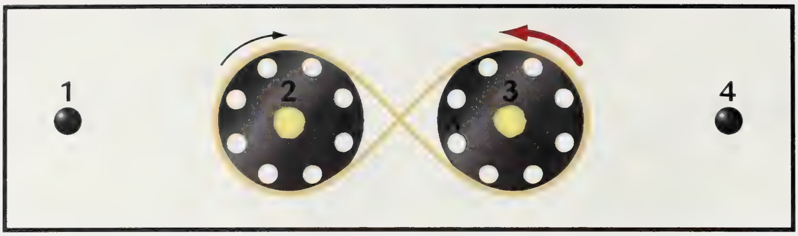
Wheel 3 rotates one turn (the same number of turns as Wheel 2 because the wheels are the same size).

9. Rotate Wheel 2 in a clockwise direction.



In which direction does Wheel 3 rotate?

Wheel 3 rotates in a counterclockwise direction (the opposite direction to Wheel 2).



10. Rotate Wheel 2 one turn. How many turns does Wheel 3 rotate?

Wheel 3 rotates one turn (the same number of turns as Wheel 2 because the wheels are the same size).

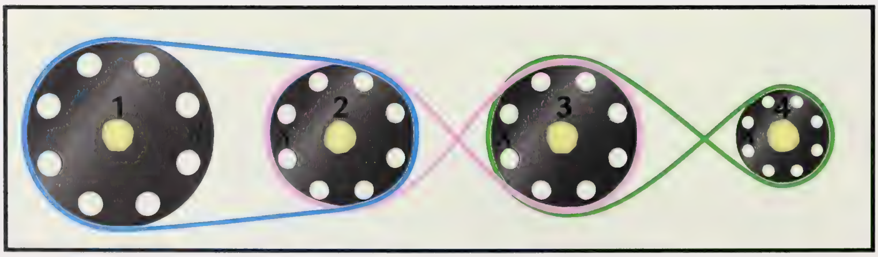
13. Rotate Wheel 1 one turn. How many turns does Wheel 2 rotate?

Wheel 2 should rotate more than one turn. A smaller wheel joined to a larger wheel will turn more times. The distance around the large wheel is greater than the distance around the small wheel.

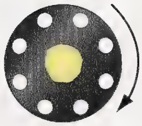
Ask an adult to help you check questions 15 to 18.

15. Sketch your drive system in the space below. Make your sketch to show your system from the top. Be sure to label wheels 1, 2, 3, and 4. Show the sizes of your wheels. Show how you placed the elastic bands. Use a different colour elastic for each connection.

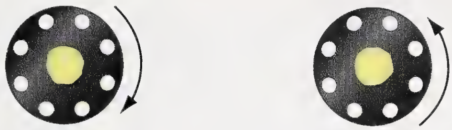
Answers will vary. Two of your wheels should be the same size. One wheel will be larger and one wheel will be smaller. The elastic bands will be in 2 loops and 1 "figure 8" **or** 1 loop and 2 "figure-8" shapes. Following is one example.



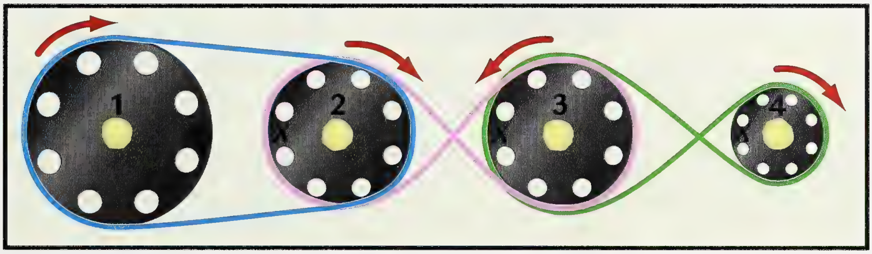
17. Rotate Wheel 1 in a clockwise direction. Watch the turning direction of the other wheels.



Are they moving clockwise? or counterclockwise?



Answers will vary. Following is one possible example of a drive system. This example has 1 loop and 2 "figure-8" shapes.



Using the given example, the answers would be as follows:

- Wheel 2: If Wheel 1 turns clockwise, Wheel 2 moves clockwise.
- Wheel 3: If Wheel 1 turns clockwise, Wheel 3 turns counterclockwise.
- Wheel 4: If Wheel 1 turns clockwise, Wheel 4 turns clockwise.

18. Do this step using your drive system. Rotate Wheel 1 one full turn. Watch how much the other wheels turn.

Answers will vary. Using the example in question 17, the answers would be as follows.

a. Which wheel moved the least?

Wheel 1 (the largest one) moved the least.

b. Which wheel moved the most?

Wheel 4 (the smallest one) moved the most.

Key Words

complex machine: a machine made up of more than one simple machine

gears: wheels with teeth on their edges

horizontal: parallel to the ground

vertical: upright or straight up and down

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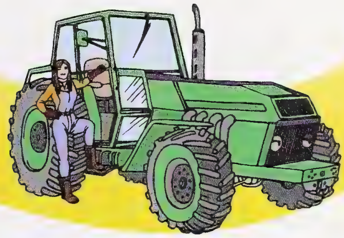
Lesson 10: Gear Up for Life!

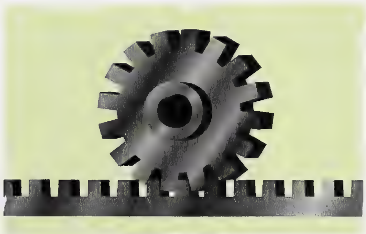


In Lesson 9, you had a chance to explore drive systems. You should have a better idea of how useful gears and pulleys can be. Have you seen gears in your home, in your yard, or in your garage? All around you, there are gears that you and your family may have been using for years! Today you are going to explore your environment to find these gears.

You may be surprised by the places you find gears. Often containers protect the gear systems. You cannot see them. You may not even know that they are there because the container hides them.

The Rack-and-Pinion Gear

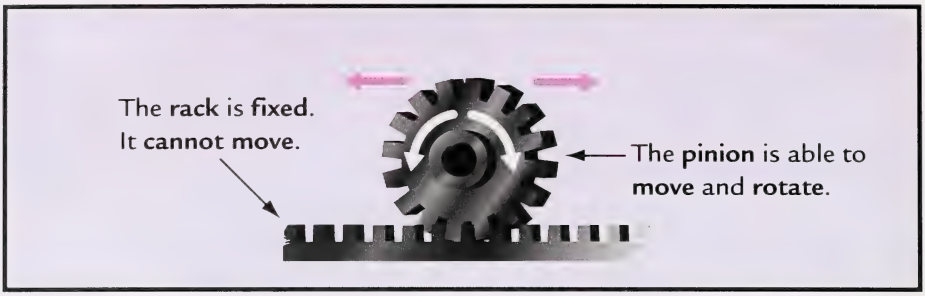
There are many different types of gears. One type is the rack-and-pinion gear.



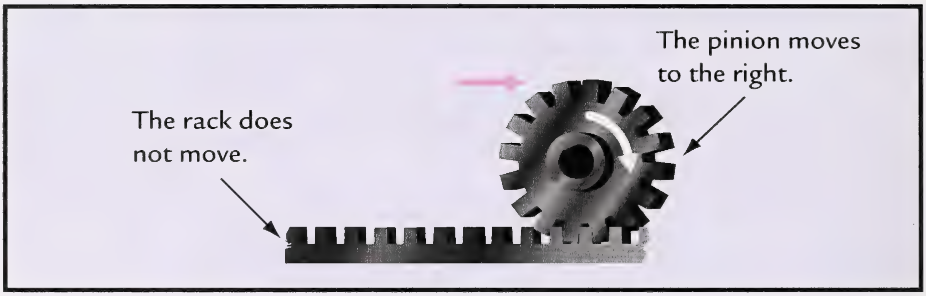
Notice the two parts of a rack-and-pinion gear. There is a flat, toothed rack and a round pinion gear. What tasks can it do? There are two parts, so you can move either part.

What happens if you turn the pinion gear?

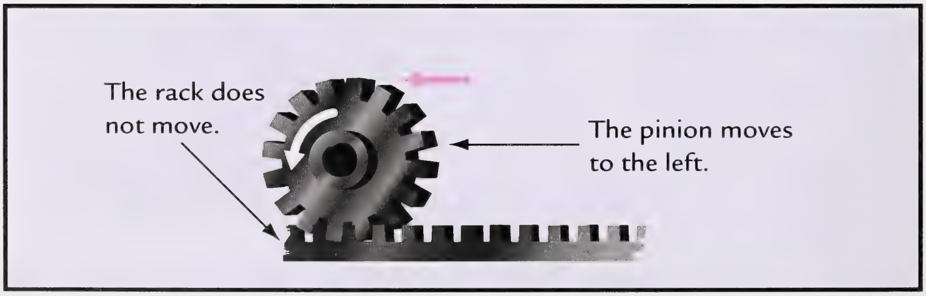
Before Turning the Pinion Gear



After Turning the Pinion Gear to the Right



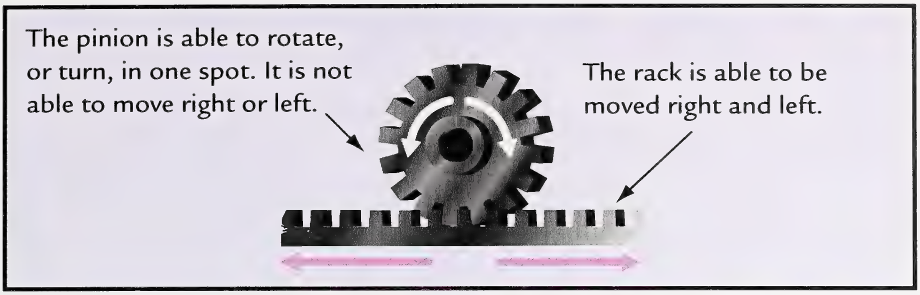
After Turning the Pinion Gear to the Left



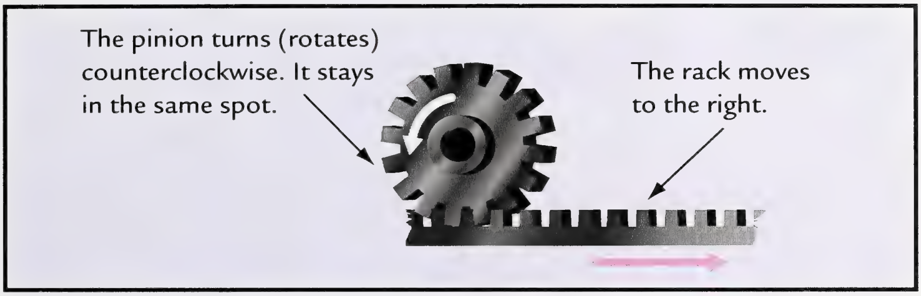
Only the pinion gear is free to move. The pinion gear rotates and moves sideways to the right and left. For this to happen, the rack must not move. It is fixed and unmovable.

What happens if you move the rack?

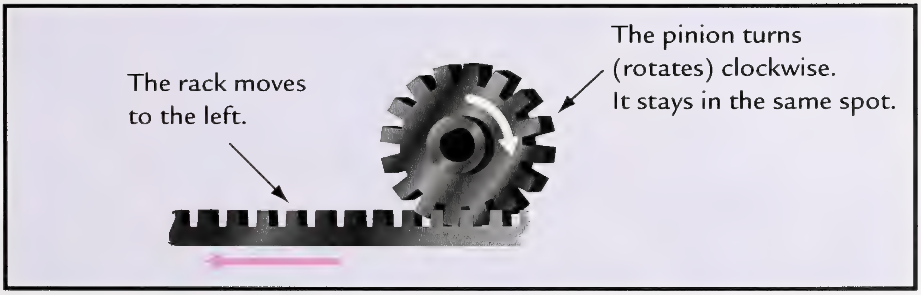
Before Moving the Rack



After Moving the Rack to the Right



After Moving the Rack to the Left



The rack is free to move left and right. The pinion gear can only rotate (turn) in a clockwise or counterclockwise direction. It cannot move right or left. It stays in one place. If you turn (rotate) the pinion gear, you can make the rack move back and forth (left and right). You have just changed a turning motion into a back-and-forth motion.

A CLOSER LOOK

Rack-and-Pinion Systems

Fixed Rack and Moving Pinion

The fixed rack and moving pinion may be found in mountain railways. One or more gears mesh with a third rail. It lets engines pull loads up very steep slopes.

Internet Link

You can see examples of rack-and-pinion railways at the following websites.

- Wikipedia's article on a rack railway

  http://www.en.wikipedia.org/wiki/Cog_railway

- The Transport Group

  http://www.transportgroup.freeserve.co.uk/images/MF10web.jpg

Movable Rack System

A car's steering system may be similar to the set-up where a pinion gear is turned and the rack moves. The turning motion changes into a back-and-forth motion. This kind of system is also found on a microscope. You use this system for focusing (making a clear image). (If you have access to a microscope, see if you can find this system.)

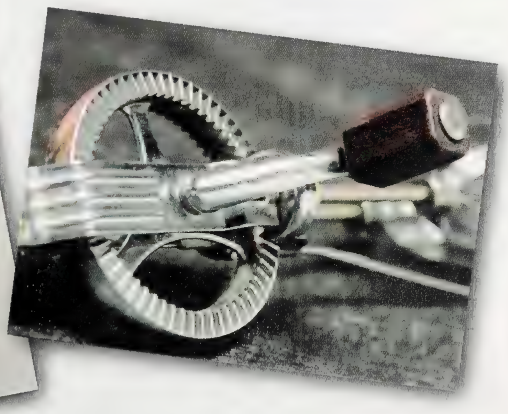
In other systems, you can move the rack back and forth (left and right) and make the pinion rotate (turn).

The Bevel Gear

A bevel gear can change the direction of the motion. For example, it can change a horizontal motion into a vertical motion (this is shown in the diagram below). You saw this gear in Lesson 9.

In the "olden days," electricity did not power most devices. Suppose you wanted to open a can of soup or beat an egg. You would have used tools that had gears.

Look in your kitchen drawers. Can you find a can opener or an eggbeater that has gears? Watch the gears rotate as you crank the handle.

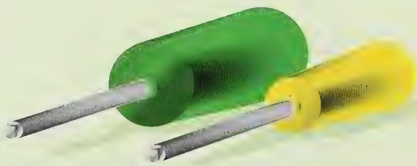


Gears that are side by side turn in opposite directions. You will find examples of this type of gear in things such as clocks and watches.

A CLOSER LOOK

Handle Power

Morgan and Leslie are building a wooden box. They are using screws to hold it together. They have two different Robertson screwdrivers. The screwdrivers are shown in the following illustration.



Morgan says, "Wow! It's really hard to turn this screw."

Leslie says, "Mine is turning really easily."

1. What colour screwdriver is Morgan using? ____________

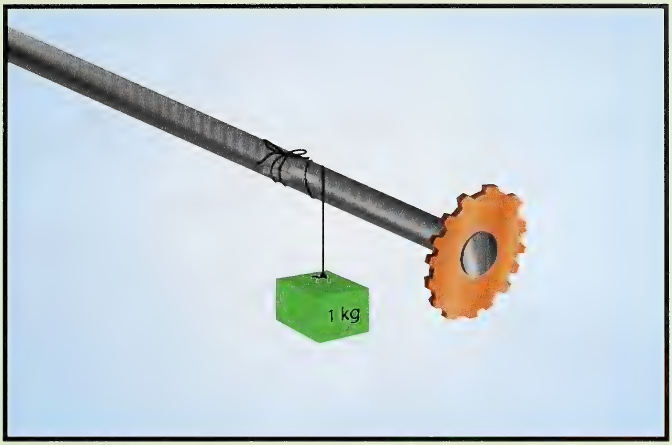
2. What colour screwdriver is Leslie using? ____________

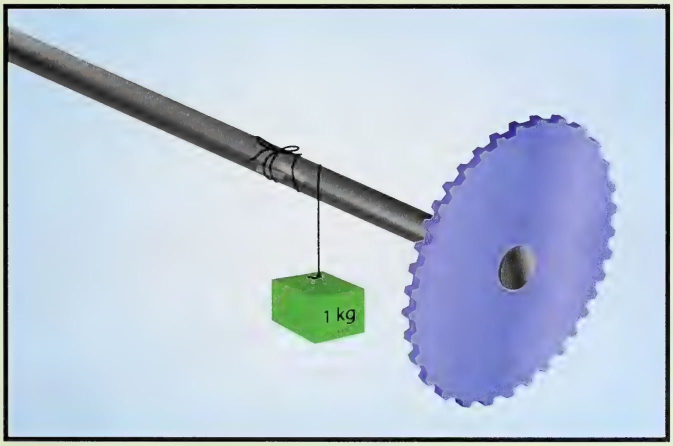
Check your answers for A Closer Look: Handle Power in the Suggested Answers at the end of this lesson.

A CLOSER LOOK

Gear Power

Look at these two illustrations. They each show a gear with an axle and an attached mass. You have to raise the mass by turning the gear.





3. Which gear will make raising the mass easier?

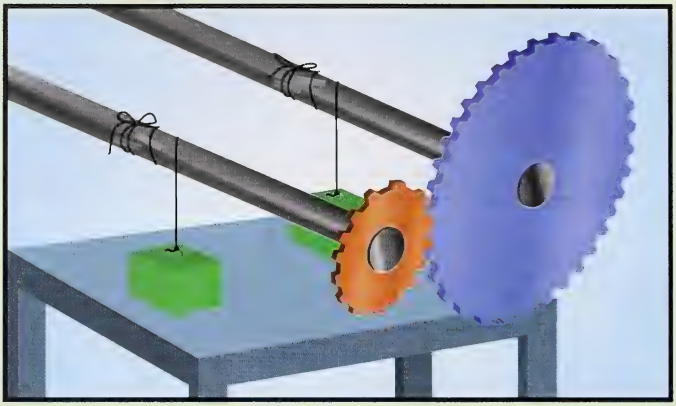
____

Check your answers for A Closer Look: Gear Power in the Suggested Answers at the end of this lesson.

A CLOSER LOOK

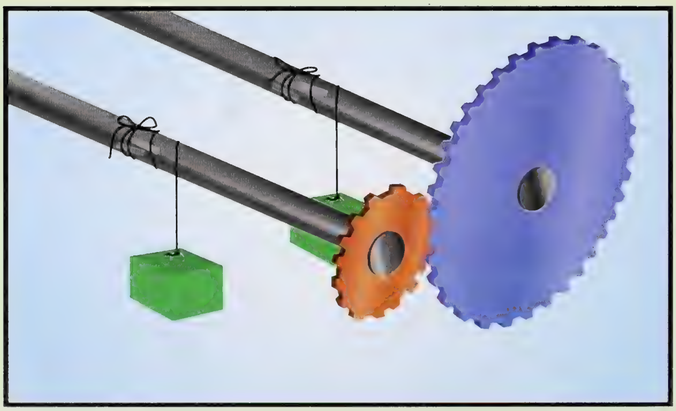
Drive Systems

The next illustration has the same gears, axles, and masses as in question 3. The gears are meshed together. The axles are supported and there is a table under the masses. Suppose you removed the table.



4. Will the gears turn? ______________________

5. Suppose the gears do turn. Which way will they turn? Mark the turning direction on each gear with an arrow.



Check your answers for A Closer Look: Drive Systems in the Suggested Answers at the end of this lesson.

Activity 10: Hide-and-Seek Gears

How good a detective are you?

What you need

- a variety of household items that use gears

What to do

In this activity, you will be searching for examples of gears. Look around your home, your family vehicle, and your surrounding area. Make sure that you have an adult with you.

It can be very dangerous to get your fingers close to gears! Electricity runs some gears. It may harm you if you attempt to uncover these gears.

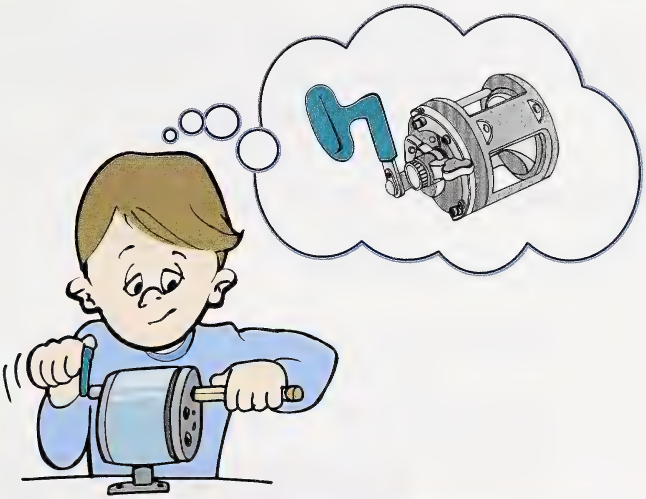
6. List five devices that you have found gears in.

- ____________________
- ____________________
- ____________________
- ____________________
- ____________________

7. For each device, draw the gears and use arrows to show the motion produced.

Check your answers for this activity in the Suggested Answers at the end of this lesson.

There are many examples of pulleys and gears in the machines around you. Friction toys, salad spinners, and clocks all include gears to help them run.



Turn to Assignment Booklet 1B and complete question 10 of the Section 3 Assignment.

Suggested Answers

A Closer Look: Handle Power

1. What colour screwdriver is Morgan using? **yellow**

2. What colour screwdriver is Leslie using? **green**

For questions 1 and 2, think about distances. The longer the distance, the less effort is needed. One turn of the small handle is a short distance. One turn of the large handle will be a longer distance. It will be harder to turn the small handle. The large handle is on the green screwdriver. It will be easier to turn.

A Closer Look: Gear Power

3. Which gear will make raising the mass easier?

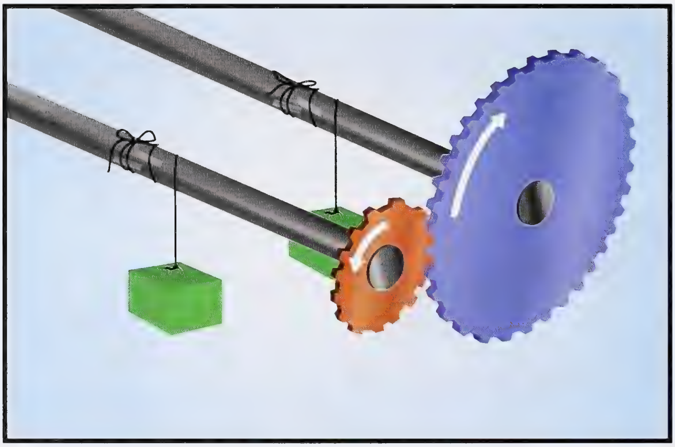
Using the large gear will make raising the mass easier. It's similar to the screwdrivers. The larger gear will travel a longer distance. It will also use less effort.

A Closer Look: Drive Systems

4. Will the gears turn?

Yes, the gears will turn.

5. Suppose the gears do turn. Which way will they turn? Mark the turning direction on each gear with an arrow.



The masses try to make both gears turn counterclockwise. Only one of the gears can turn counterclockwise. (Remember that meshed gears turn in opposite directions.) Which gear will win this struggle? Think about your answer to question 2. The large gear is easier to turn than the small one.

The mass attached to the small gear wins. It will turn the small gear counterclockwise. The small gear will make the large gear turn. The large gear will turn clockwise.

Activity 10: Hide-and-Seek Gears

1. List five devices that you have found gears in.

Answers will vary. These are some possible examples:

- windshield wipers
- automobile transmissions
- lamp switches
- hand-crank pencil sharpeners
- spinning tops
- tape recorders
- VHS players
- drills
- can openers
- eggbeaters
- toys
- bikes
- watches
- clocks

7. For each device, draw the gears and use arrows to show the motion produced.

Answers will vary based on the items found. A sample using a hand drill is given.

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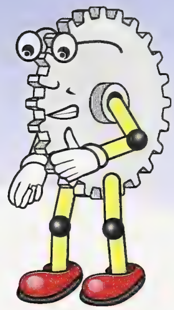
Section 3

Conclusion



As you look around you at the things that move, you find all kinds of examples of gears. In this section, you have seen how to use gears to transfer movement. You have found gears in your home and in everyday things that you use. Are you ready to set these gears in motion?

Optional Follow-up Activities

Activity 1: Balancing a Teeter-Totter

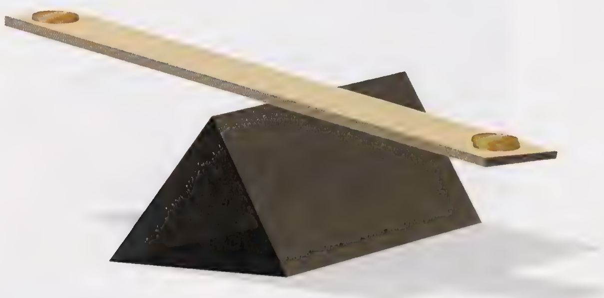
How would you balance a teeter-totter level on its fulcrum if one person is twice as heavy as the other?

What you need

- 3 pennies
- a 30-cm ruler
- a cardboard triangular block

What to do

Use a ruler as your lever and a cardboard triangular block as your fulcrum. Place two pennies on one end of the ruler and one penny on the other end. What do you have to do to balance the lever?



Activity 2: Making a Lever Scale

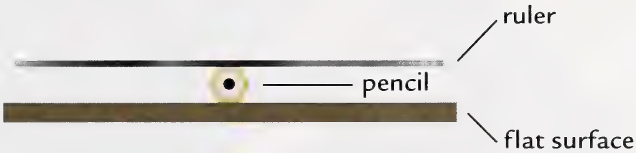
You can use a lever to weigh things. Use the chart in Section 2: Activity 7 (page 69) and some Canadian coins to weigh small objects around you. Perhaps you want to know the mass of your pen, a small toy, or a DVD. Build your own scale.

What you need

- some coins
- a ruler
- a hexagonal pencil
- various small objects to weigh
- a felt pen

What to do

Look at the diagram to help with this activity.



1. Place the pencil on a flat surface, such as a counter top or table. Sit the ruler on the pencil and balance it. The ruler should be above the table surface at both ends. Mark the sides of the pencil on the ruler. You can use the marks to balance the ruler quickly.

2. Put the centre of the object you are weighing at the 30-cm mark on the ruler.

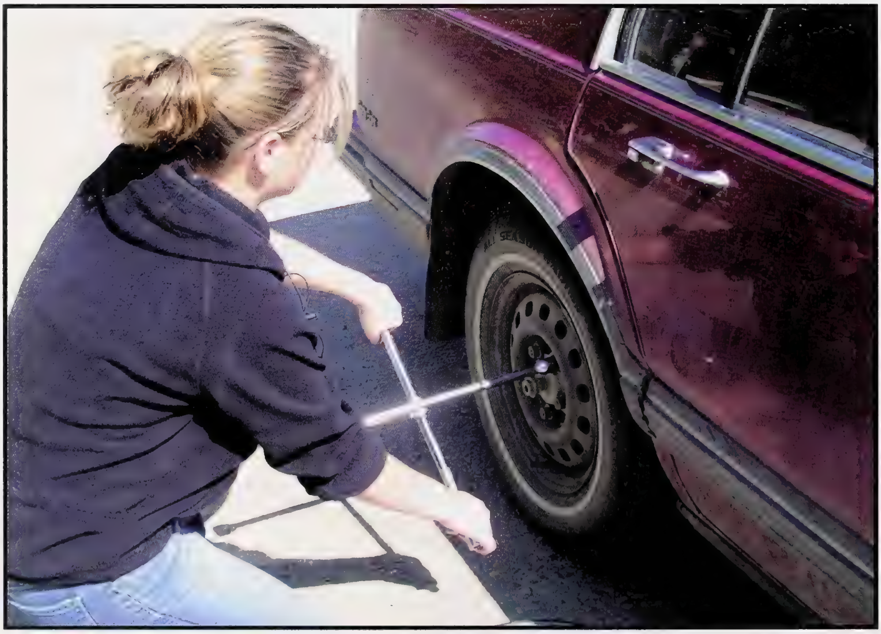
3. Stack coins at the 0-cm mark until the object just lifts off the surface of the table.

4. Write down the weight of your object. (Does it seem strange to say a pen weighs $1.35? Perhaps an adult can help you convert your pile of money into grams.)

Module Summary

Did you enjoy playing with simple machines in this module?

There are only six types of simple machines in the world, and you have explored and experimented with all six! You saw examples of how inclined planes, wedges, screws, levers, wheel-and-axle devices, and pulleys help you do work more easily. Don't you wish there was a seventh simple machine that could help you do homework?



Now turn to the checklist in Assignment Booklet 1B and make sure you have collected everything to send to your teacher.

Glossary

block and tackle: a type of compound pulley

compound pulley: a pulley system with more than one rope and wheel

effort: force applied to a machine to move an object

fixed pulley: a pulley attached to something that does not move

fixed: does not move

force: a push or a pull acting upon an object

friction: a force that opposes the motion between two objects in contact with each other

fulcrum: fixed point on a lever

gears: wheels with teeth on their edges

horizontal: parallel to the ground

inclined plane: a simple machine with a slope, such as a ramp

lever: a stiff bar or rod that pivots around a fixed point

load: object or material to be moved

machine: anything that helps us perform a task more easily

movable pulley: a pulley that moves with the load

pivot: to move around a fixed point

projectile: a missile for a weapon

pulley: a wheel-and-axle system used to change the direction of applied force

simple machine: a basic machine like the inclined plane, lever, pulley, screw, wedge, and wheel and axle

simple pulley: a pulley with one wheel

theory: a general rule that explains or predicts facts or events

threads: sloping ridges that wind or coil around a screw, bolt, or jar lid

trebuchet: a medieval military machine for hurling heavy missiles (such as rocks)

vertical: upright or straight up and down

wedge: a simple machine used to separate materials; two inclined planes together

wheel and axle: a simple machine made up of an attached wheel and cylinder